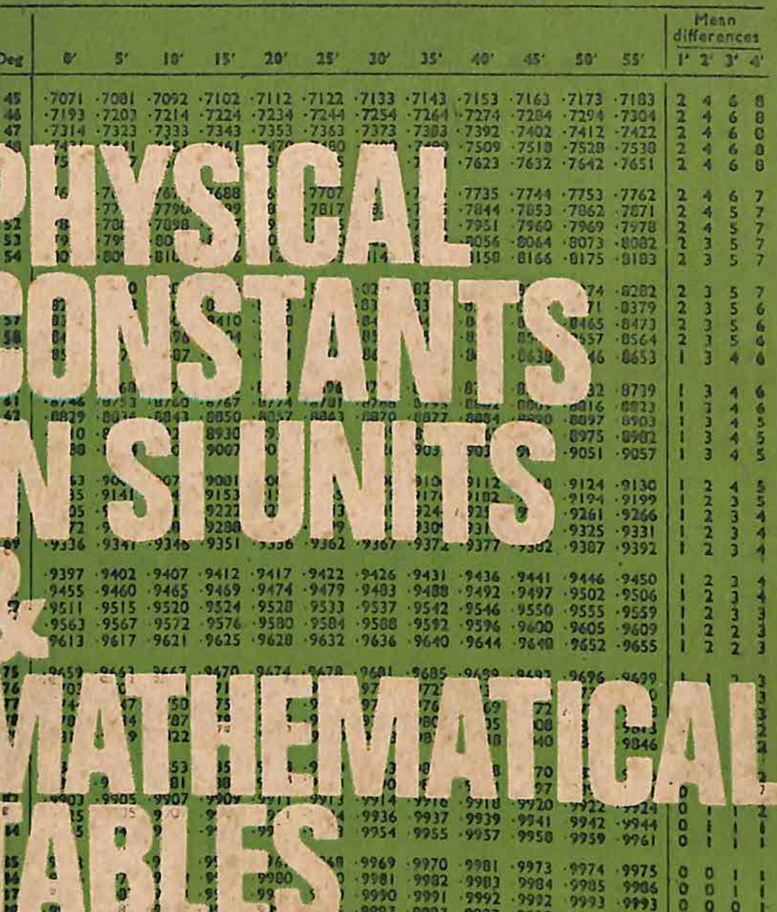

PHYSICAL CONSTANTS IN SI UNITS & MATHEMATICAL TABLES

V.V.L. RAO
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ORIENT LONGMAN

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Physical Constants in SI Units and Mathematical Tables

Revised Edition

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Preface to Second Edition

The first edition of this book which was put on the market in February 1972 was quickly sold out and hence a partly revised edition had to be urgently published in November 1972 to meet the pressing demand. Since then a thorough revision has been done and the entire work has fallen on me due to the sad and sudden demise of my esteemed former colleague and co-author Prof. V. V. L. Rao in August 1970 soon after we had handed over the typescript of this book to the publishers.

Considerable additional matter has been included in this edition, much at the specific requests of college lecturers and professors, who have found this book extremely useful and valuable. It is now hoped that this book will serve a larger student community. As expressed in the preface to the first edition, I am grateful to Dr. P. J. Fargo, Editor of *Chemistry in Britain* and Prof. N. N. Greenwood for according permission to reproduce the 'Periodic Table' from Prof. Greenwood's article in the March 1970 issue of *Chemistry in Britain*. Many standard publications like *Tables of Physical and Chemical Constants* by G. W. C. Kaye and T. H. Laby (Longman), *Handbook of Chemistry and Physics* (Chemical Rubber Company, Cleveland, Ohio, USA), *Physical and Mathematical Tables* by J. B. Clarke (Oliver and Boyd), *Handbook of Physical Constants and Mathematical Tables* by T. N. Seshadri, etc, have been consulted for compiling the uptodate values of the data given in this book. My grateful thanks are due to them. I am also grateful to Orient Longman for their keen interest in the publication of this book and pricing it low enough to be within easy reach of even the poorest student.

In spite of my best efforts some errors may have crept in. I shall be grateful to the readers who spot such errors, which may by kindly communicated to the publishers so that they may be corrected in the next edition.

Suggestions for increasing the usefulness of this book for a wider section of scientific community are welcome.

Madras, 1975 K. S. B. ESWARAN

Extract from Preface to the First Edition

In the context of the worldwide changeover to the use of SI units, a need has been felt for compiling physical and chemical data in SI units. Hence this book. Mathematical tables have been added to enhance its utility. This book is meant for use by students from the high school level through college, upto the degree level in science, engineering and technology.

Madras **V. V. L. RAO**
20th May, 1970 **K. S. B. ESWARAN**

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PART I

SI Units, Signs, Symbols

Abbreviations and Definitions

Table 1: SI Units, Names and Symbols

Physical quantity	Symbol for physical quantity	SI unit	Symbol for SI unit
1. length	l	metre	m
2. mass	m	kilogram	kg
3. time	t	second	s
4. electric current	I	ampere	A
5. thermodynamic temperature	T	kelvin	K*
6. luminous intensity	I_v	candela	cd
7. amount of substance	n	mole	mol

* The symbol (°) and the word degree should not be used with the kelvin.

Table 2: Supplementary Units

1. plane angle	θ	radian	rad
2. solid angle	ω	steradian	sr

Table 3: Prefixes for Units to indicate multiples and sub-multiples of the Units

Name (Multiples)	Symbol	Multiplying factor	Name (sub-multiples)	Symbol	Multiplying factor
tera	T	10^{12}	deci*	d	10^{-1}
giga	G	10^{9}	centi*	c	10^{-2}
mega	M	10^{6}	milli	m	10^{-3}

Table 3: Prefixes for Units to indicate multiples and sub-multiples of the Units (Contd.)

kilo	k	10^{3}	micro	μ	10^{-6}
hecto*	h	10^{2}	nano	n	10^{-9}
deka*	da	10	pico	p	10^{-12}
			femto	f	10^{-15}
			atto	a	10^{-18}

*To be used only when there is a strongly felt need.

Notes :

1. Compound prefixes should not be used, e.g., 10^{-9} m$=1$ nm, not 1 mμm. No space should be left between the prefix and the unit.
2. The attaching of a prefix to a unit in effect constitutes a new unit, e.g., $1\ \text{km}^2=(1\ \text{km})^2=10^6\ \text{m}^2$
   $1\ \text{km}^2 \neq 10^3\ \text{m}^2$.

Table 4: Derived units with Special Names

Physical quantity	Symbol for physical quantity	SI unit	Symbol for SI unit	Definition of unit
force	F	newton	N	$\text{Kg m s}^{-2}=\text{Jm}^{-1}$
energy	E, W	joule	J	$\text{Nm}=\text{kg m}^2\,\text{s}^{-2}$
power	P	watt	W	$\text{Js}^{-1}=\text{kg m}^2\,\text{s}^{-2}$
pressure	p	pascal	Pa	Nm^{-2}
electric charge	Q	coulomb	C	As
electric potential difference	U	volt	V	$\text{JQ}^{-1}=\text{kg m}^2\,\text{s}^{-3}\,\text{A}^{-1}$
electric resistance	R	ohm	Ω	$\text{VA}^{-1}=\text{kg m}^2\,\text{s}^{-3}\,\text{A}^{-2}$
electric conductance	G	siemens	S	Ω^{-1}
electric capacitance	C	farad	F	$\text{QV}^{-1}=\text{A}^2\,\text{s}^4\,\text{kg}^{-1}\text{m}^{-2}$
magnetic flux	ϕ	weber	Wb	$\text{Vs}=\text{kg m}^2\,\text{s}^{-2}\,\text{A}^{-1}$
magnetic flux density (magnetic induction)	B	tesla	T	$\text{Wb m}^{-2}=\text{kgs}^{-2}\,\text{A}^{-1}$
inductance	L, M	henry	H	$\text{Vs A}^{-1}=\text{kgm}^2\,\text{s}^{-2}\text{A}^{-2}$
frequency	ν, f	hertz	Hz	s^{-1}
temperature	θ, t	degree celsius	°C	
luminous flux	Φ	lumen	lm	cd sr
illumination	E	lux	lx	$\text{lm m}^{-2}=\text{Cd sr m}^{-2}$

Table 5: Some derived SI Units with symbols*

Physical quantity	Symbol for physical quantity	SI unit	Symbol for SI unit
area	A	square metre	m^2
volume	V	cubic metre	m^3
mass density	ρ	kilogram per cubic metre	$kg\ m^{-3} = kg/m^3$
velocity	u, v, w	metre per second	$ms^{-1} = m/s$
angular velocity	ω	radian per second	$rad\ s^{-1} = rad/s$
acceleration	a	metre per second per second	$ms^{-2} = m/s^2$
angular acceleration	α	radian per second per second	$rad\ s^{-2} = rad/s^2$
kinematic viscosity	λ	square metre per second	$m^2\ s^{-1}$
dynamic viscosity	η	newton second per square metre	Nsm^{-2}
electric field strength	E	volt per metre	Vm^{-1}
magnetic field strength	H	ampere per metre	Am^{-1}
entropy	S	joule per kelvin	JK^{-1}
permeability	μ	henry per metre	Hm^{-1}
permittivity	ϵ	farad per metre	Fm^{-1}
luminance	L, L_v	candela per square metre	$cd\ m^{-2}$

* This list is merely illustrative and not exhaustive.

Table 6: Units which may be used together with the SI Units

(These units are not part of SI)

Physical quantity	Name of unit	Symbol for unit	Definition of unit or value
time	minute	min	1 min = 60 s
	hour	h	1 h = 60 m
	day	d	1 d = 24 h
plane angle	degree	°	$1° = (\pi/180)$ rad
	minute	′	$1' = (1/60)°$
	second	″	$1'' = (1/60)$

Table 6: Units which may be used together with the SI Units (Contd.)

energy	electron volt	eV	$\approx 1{\cdot}602\,1 \times 10^{-19}$ J*
mass	unified atomic mass unit	u	$\approx 1{\cdot}660\,41 \times 10^{-27}$ kg*
length	astronomical unit	AU	$\approx 1{\cdot}496 \times 10^{6}$ km*

* The values of these units are subject to change in the light of new experimental measurements of the constants involved.

This list is not exhaustive.

Table 7: Special names and symbols for decimal fractions and multiples of some SI Units

(These names are not part of the SI. Except in special circumstances their use is not recommended and should be progressively abandoned.)

Physical quantity	Name of unit	Symbol for unit	Value of the unit
length	ångstrom	Å	10^{-10} m = 10^{-1} nm
length	micron	μm	10^{-6} m
area	hectare	ha	10^{4} m^{2}
area	are	a	10^{2} m^{2}
area	barn	b	10^{-28} m^{2}
volume	litre	l	10^{-3} m^{3} = dm^{3}
mass	tonne	t	10^{3} kg = Mg
force	dyne	dyn	10^{-5} N
pressure	bar	bar	10^{-5} Nm^{-2}
acceleration	gal	Gal	1 cm s^{-2} = 10^{-2} m s^{-2}
kinematic viscosity	stokes	St	10^{-4} m^{2} s^{-1}
dynamic viscosity	poise	p	10^{-1} kgm^{-1} s^{-1}
energy	erg	erg	10^{-7} J
magnetic flux	maxwell	Mx	10^{-8} Wb
magnetic flux density (magnetic induction)	gauss	G	10^{-4} T

Table 8: Other Units

(These units are not part of the SI. Except in special circumstances their use is not recommended and should be progressively abandoned.)

Physical quantity	Name of unit	Symbol for unit	Value of the unit
length	Parsec	pc	$3{\cdot}085\,6 \times 10^{13}$ km
length	nautical mile	—	1 International nautical mile = 1 852 m
velocity	knot	—	1 nautical mile/hour
pressure	standard atmosphere	atm	101 325 Nm^{-2}
pressure	torr	torr	(101 325/760) Nm^{-2}
energy	kilowatt-hour	kwh	$3{\cdot}6 \times 10^{6}$ J
radio activity	curie	Ci	$3{\cdot}7 \times 10^{10}\ \mathrm{s}^{-1}$
ionization exposure	roentgen	R	$2{\cdot}58 \times 10^{-4}$ C/kg
absorbed dose	rad	rad	10^{-2} J/kg

Footnotes

1. The astronomical unit and parsec are used to express astronomical data.

2. The nautical mile and knot are special units used in sea and air navigation.

3. The gal is a special unit used in geodesy and geophysics for expressing acceleration of free fall.

4. The barn is a special unit used in nuclear physics for expressing the cross-section for a specified reaction.

5. The curie is a unit used in nuclear physics for expressing the activity of radio nuclides.

6. The roentgen is a unit used for expressing radiation dosage.

7. The rad is a unit used for expressing the absorbed dose of ionizing radiation.

8. The kilowatt-hour is a unit used to express electrical energy.

9. The ångstrom is used to express the wave-lengths of spectral lines in spectroscopy.

10. The micron is largely used in metereology and cloud physics.

9. DEFINITIONS OF SI UNITS

A. Base Units

1. Metre (m)

The metre is the length equal to 1 650 763·73 wave-lengths in vacuum of the radiation corresponding to the transition between the levels $^2p_{10}$ and $^5d_5$ of the krypton-86 atom.

2. Kilogram (kg)

The kilogram is the unit of mass; it is equal to the mass of the International prototype of the kilogram kept at the International Bureau of Weights and Measures at Sevrés.

3. Second (s)

The second is the duration of 9 192 631 770 periods of the radiation corresponding to the transition between the two hyperfine levels of the ground state of the caesium-133 atom.

4. Ampere (A)

The ampere is that constant current which, if maintained in two straight parallel conductors of infinite length and negligible circular cross-section placed 1 m apart in vacuum, will produce between them a force equal to 2×10^{-7} newton per metre length.

5. Kelvin (K)

The kelvin, unit of thermodynamic temperature, is the fraction 1/273·16 of the thermodynamic temperature of the triple point of water.*

6. Candela (cd)

The candela is the luminous intensity, in the perpendicular direction, of a surface of 1/600 000 square metre of a black body at the temperature of freezing platinum under a pressure of 101 325 newtons per square metre.

7. Mole (mol)

It is the amount of substance in a system containing as many elementary entities as there are atoms in 0·012 kg of carbon-12. While using the mole the elementary entities should be specified and may be atoms, molecules, ions, electrons, or other particles, or specified groups of such particles.

B. Supplementary Units

1. Radian (rad)

The radian is the plane angle between two radii of a circle which cut off on the circumference an arc equal in length to the radius.

---

* Triple point of water = 273·16K. Ice point (0°C) = 273·15K

2. Steradian (sr)

The steradian is the solid angle which, having its vertex in the centre of a sphere, cuts off an area of the surface of the sphere equal to that of a square with sides of length equal to the radius of the sphere.

C. Mechanics

1. **Force** (*F*): The unit of force is the newton. It is that force which, when applied to a body having a mass of one kilogram gives it an acceleration of one metre per second per second.
   Unit: $N = kg\ ms^{-2}$
2. **Energy or Work** (*E, W*): The unit of energy is the joule. It is the work done when the point of application of a force of one newton is displaced through a distance of one metre in the direction of the force,
   Unit: $J = Nm = kg\ m^2\ s^{-2}$
3. **Power** (*P*): The unit of power is the watt. It is equal to one joule per second. Unit: $W = Js^{-1}$
   1 kilowatt = 1 000 W
4. **Pressure** (p): The unit of pressure is the pascal. It is equal to one newton per square metre. Unit: $Pa = Nm^{-2}$
5. **Momentum**: It is equal to mass × velocity. Unit: $kg\ ms^{-1}$
6. **Viscosity** (*dynamic*) (η): The coefficient of viscosity is the tangential force per unit area between two parallel layers in a fluid separated by unit distance when one layer is moving in its own plane with unit velocity relative to the other. Unit: Nsm^{-2}
7. **Viscosity** (*kinematic*) $(\nu) = \eta / \rho$. Unit: $m^2\ s^{-1}$
8. **Surface Tension** (γ): The coefficient of surface tension of a liquid is the force acting across a line of unit length taken anywhere in its surface. Unit: Nm^{-1}

D. Amount of substance

In the field of chemistry and molecular physics, it is often found necessary to specify an amount of substance in terms of a fixed number of constituent parts. In SI this is done with reference to the number of atoms in 0·012 kg of the isotope of carbon – 12 which contains, 6 protons and 6 neutrons in its nucleus. Unit of '*amount of substance*' is the 'mole' (mol) and it is one of the base units in SI.

Examples

1 mole of HgCl has a mass equal to 0·236 04 kilogram

1 mole of e^{-1} has a mass equal to $5{\cdot}486 \times 10^{-7}$ kilogram

9. Definitions of SI Units (Contd.)

Unified mass unit (u): This is exactly 1/12th the mass of the pure carbon atom $^{6}C^{12}$

Avogadro constant is defined as the number of atoms in 0·012 kg of the isotope $^{6}C^{12}$ and is thus the number of entities in a mole of substance.

E. Heat

Heat is a form of energy

Temperature (t, T)

The SI base unit is the kelvin. The units of kelvin (K) and Celsius (°C) temperature intervals are identical. A temperature expressed in degrees Celsius is equal to the temperature expressed in kelvins less 273·15

$$t°C = K - 273{\cdot}15$$

Quantity of Heat (Q)

Quantities of heat are measured in joules (J). Other units like the calorie and British Thermal Unit (Btu) are not permitted.

Specific Heat Capacity (C_p, C_v)

It is the amount of heat in joules required to raise the temperature of 1 kg of a substance by 1 K. Unit: $J\ kg^{-1}\ K^{-1}$

Specific Latent Heat (l): The specific latent heat of $\left(\frac{\text{fusion}}{\text{vapourization}}\right)$ of a substance is the amount of heat required to convert 1 kilogram of substance at its $\left(\frac{\text{melting point}}{\text{boiling point}}\right)$ into $\left(\frac{\text{liquid}}{\text{vapour}}\right)$ at the same temperature. Unit: $J\ kg^{-1}$.

Molar Heat Capacity (C_m): This is the amount of heat required to raise the temperature of 1 mol of a substance through 1K. Unit: $J\ mol^{-1}\ K^{-1}$.

Thermal Conductivity (λ): It is the heat flowing per second between two parallel faces of unit area of the substance when the faces are unit distance apart and are maintained at a temperature difference of 1 K with all the heat entering through one face and leaving through the other.

$$\frac{dQ}{dt} = -\lambda A \frac{dT}{dx}$$

Unit: $Jm^{-1}\ s^{-1}\ K^{-1}$ or $Wm^{-1}\ K^{-1}$

Linear expansivity (α) of a substance is the increase in length per unit length per unit rise in temperature. Unit: K^{-1}

Cubic expansivity (γ) of a substance is the increase in volume per unit volume per unit rise in temperature. Unit: K^{-1}

Critical Temperature (T_c) of a gas or vapour is that temperature above which it is not possible to liquify the gas by the application of pressure alone. To liquify a gas it has to be cooled below its critical temparature before compressing it.

Critical Pressure (P_c) of a gas is that pressure which just liquifies it at its critical temperature.

Critical Volume (V_c) is the volume of unit mass of gas at its critical temperature and pressure, i.e., it is the reciprocal of the critical density.

Entropy (S) : When in a reversible change a substance takes in a quantity of heat dQ at T(K) its increase in entropy is d Q/T. Unit of specific entropy : J Kg^{-1} K^{-1}.

Enthalpy (H) : When a substance under constant pressure P takes in a quantity of heat Q which is spent only on increasing its internal energy and performing positive or negative external work, the increase of enthalpy $(H_2 - H_1)$ is given by $(E_2 + P V_2) - (E_1 + PV_1) = Q$ where E is the internal energy and V the volume of the substance. Unit of specific enthalpy : J kg^{-1}.

F. Light

Light is a form of radiant energy which produces the sensation of light through the eye.

Luminous Intensity (I) : It is the luminous flux radiated per unit solid angle (i.e., solid angular density of flux) measured in the direction in which the intensity is required The unit of luminous intensity is the candela (cd) which is one of the base units.

1 cd = 0·982 international candles

Luminous Flux (ϕ) is the light energy radiated per second from a luminous body. It is therefore a form of power. The unit of flux is the lumen (lm) It is the flux emitted within unit solid angle of one steradian by a point source having a uniform intensity of one candela (cdsr).

Illumination (E) of a surface is measured by the luminous flux reaching it per unit area of surface. The unit of illumination is the lux (lx) which is one lumen per square metre (lm/m^2).

Brightness of a surface is that property by which the surface appears to emit more or less light.

Brightness of a source as judged by the eye is referred to as

Subjective Brightness or Luminosity. It depends upon a number of factors like the nature of the surrounding surface etc.

9. Definitions of SI Units (Contd.)

Photometric measurements of brightness of a source in terms of candelas per unit of projected area are definite as other factors like the nature of the surrounding surface etc., do not affect the measurements. Such interpretations of the brightness of a source are referred to as *objective brightness* or *photometric luminance.* Luminance and luminosity are not proportional to each other.

Luminance of a source in a given direction is the luminous intensity in that direction per unit of projected area. The unit of luminance is the *nit* which is equal to one candela per square metre of projected area (cdm^{-2}).

The Lumen Hour is the unit of quantity of light. It is the quantity of light delivered in one hour by a flux of one lumen (lm-h).

The Refractive index *(n)* of a material is the ratio of the velocity of light in free space to that in the material.

Snell's Law: For a ray of light which is incident on a boundary between two media of different densities the ratio of the sine of the angle of incidence (i.e., the angle between the ray of light in the first medium and the normal to the boundary surface) to the sine of the angle of refraction (i.e., the angle between the refracted ray in the second medium and the normal) is a constant equal to the reciprocal of the ratio of refractive indices of the two media.

Dioptre: It is the unit in which the power of an optical lens is measured and is numerically equal to the reciprocal of the focal length expressed in metres.

G. Electricity and Magnetism

1. **Current** *(I):* The unit of current is the *ampere* which is one of the base units in SI.
2. **Charge** *(Q):* The unit of charge (quantity) is the *coulomb* (C). It is the quantity of electricity transported in one second by a current of one ampere.
3. **Potential Difference** *(V):* The unit of electrical potential difference is the *volt* (V). It is the difference of electric potential between two points of a conducting wire carrying a constant current of 1 ampere, when the power dissipated between these points is equal to one watt.
4. **Resistance** *(R):* The unit of electric resistance is the *ohm* (Ω). It is the electric resistance between two points of a conductor when a constant difference of potential of 1 volt applied between these points, produces in this conductor a current of 1 ampere, the conductor itself not being the source of any electromotive force.

9. Definitioins of SI Unts (Contd.)

5. **Conductance** *(G)*: The unit of conductance is the *siemens* (S). It is defined as the electrical conductance between two points of a conductor when a constant potential difference of 1 volt applied between these points produces in it a current of 1 ampere.

6. **Inductance** *(L)*: The unit of inductance is the *henry* (H). It is the inductance of a closed circuit in which an electromotive force of 1 volt is produced when the electric current in the circuit varies uniformly at the rate of 1 ampere per second.

7. **Capacitance** (C) The unit of capacitance is the *farad* (F). It is the capacitance of a capacitor between the plates of which there appears a difference of potential of 1 volt when it is charged by a quantity of electricity equal to one coulomb.

8. **Frequency** (ν, f): The unit of frequency is the hertz (Hz). It is the frequency of a periodic phenomenon of which the periodic time is one second, i.e., one cycle per second.

9. **Magnetic Flux** (ϕ): The unit of magnetic flux is the *weber* (Wb). Theweber is the magnetic flux which, linking a circuit of one turn, produces in it an electromotive force of 1 volt as it is reduced to zero at a uniform rate in 1 second.

10. **Magnetic Flux Density or Induction** (B): The unit of magnetic flux density is the *tesla* (T). It is the density of one weber of magnetic flux per square metre.

    Note 1. Magnetic flux ϕ can also be defined from the equation

    $\phi = \int Bn\, da$ where n is a unit vector perpendicular to an element of area da

    2. Magnetic flux density or Induction (B) can be defined from the equation $F = B \cdot i \cdot ds \sin\theta$
    where F is the force on a current element placed in a magnetic field.

11. **Magnetic Intensity** (H): It is defined by Biot-Savart law for the intensity due to a current element. In the usual notation,

    $H = \dfrac{i\, dl \sin\theta}{4\pi r^2}$. Unit: ampere/metre ($Am^{-1}$)

12. **Magnetic Moment** (m): It is the couple exerted on a magnet placed at right angles to a uniform field of unit flux density. Unit: ampere metre^2: (Am^2)

13. **Intensity of Magnetisation** (M): It is the magnetic moment per unit volume of a magnet: Unit: ampere metre^{-1} (Am^{-1})

14. **Magnetomotive Force** (F_m): It is defined as the line integral $\oint H dl$ evaluated for a closed path. Unit: ampere-turn (A)

15. **Pole Strength** (P): A unit magnetic pole can be defined as one which when placed at a distance of 1 metre in vacuum from an equal pole experiences a force of $\mu_o/4\pi$ newtons. It can also be defined as that pole strength which will experience a force of 1 newton when placed in a field of unit flux density.
Unit: ampere metre (Am)

16. **Magnetic Permeability** (μ): It is defined as the ratio of the magnetic induction in the material to the magnetic field producing it, that is $\mu = \frac{B}{H}$ and $\mu = \mu_o \mu_r$ where μ_o = the permeability of free space and μ_r is the relative permeability of the medium, relative to free space. μ_r is a pure number and $\mu_o = 4\pi \times 10^{-7}$ H/m.
Unit: henry metre^{-1} (Hm^{-1})

17. **Electric Field Strength** (E): The electric intensity at a point in an electric field is the force exerted on unit charge (1 coulomb) placed at that point, assuming that the field is not disturbed by the introduction of this charge. Unit: newton coulomb^{-1} (NC^{-1}) which is equivalent to volt metre^{-1} (Vm^{-1}).

18. **Relative Permittivity** (ϵ_r): It is defined as the ratio of the capacitance of a capacitor having a certain dielectric to the capacitance of the same capacitor with vacuum (or air) as dielectric. It is a pure number.

19. **Permittivity** (ϵ): It is defined by the equation $\epsilon = \epsilon_o \cdot \epsilon_r$ where ϵ_o is the permittivity of free space or electric space constant

$$\epsilon_o = 8{\cdot}85 \times 10^{-12} \text{ F/m}$$

20. **Permittivity of Free Space** (ϵ_o): It is the ratio of the electric flux density in a vacuum to the electric force. Unit: farad metre^{-1} (Fm^{-1})

COULOMB'S LAWS

1. Electrostatics

$$F = \frac{Q_1 Q_2}{4\pi \epsilon_o \epsilon_r l^2}$$

where Q_1, and Q_2 are the two charges situated a distance l apart in a medium whose permittivity relative to that of free space is ϵ_r and ϵ_o is the permittivity of free space.

$$\epsilon_o \simeq (1/36\pi) \times 10^{-9} \text{ farad/metre}$$

2. Megnetism

The law states that the force between two poles P_1 and P_2 situated distance l apart is given by

$$F = \frac{\mu_0 \mu_r P_1 P_2}{4\pi l^2}$$

where μ_r is the relative permeability of the medium and μ_0 the permeability of free space

$$\mu_0 = 4\pi \times 10^{-7} \text{ henry/metre}$$

H. Sound

Sound is a type of wave motion propagated in an elastic medium which transmits energy. It is also the sensation produced through the ear by the sound waves.

Frequency (ν, f): It is the number of cycles occuring per unit of time. Unit: Hz

Wave length (λ): The wave length of a sound wave in an isotropic medium is the perpendicular distance between two wave fronts in which the displacements have a phase difference of one complete cycle.

Octave is the interval over which the ratio of extreme frequencies equals 2. The interval $\nu_2 - \nu_1$ is equal to one octave, if the ratio ν_2/ν_1 of the extreme frequencies is equal to 2.

Pressure: The sound pressure at a point is the root mean square value of the instantaneous sound pressure over a complete cycle at that point. The unit of sound pressure is the *pascal*.

Threshold of hearing is for a normal observer the sound level or intensity which is just audible. For a pure sinusoidal note of frequency 1000 Hz, it is close to root mean square pressure of $2{\cdot}04 \times 10^{-5}$ Pa.

Power Level: The unit of acoustical (or electrical) power level measurements with reference to a standard power level is one bel. The interval between two powers W_1 and W_0 in bels $= \log_{10}\left(\frac{W_1}{W_0}\right)$

One bel = 10 decibels (dB).

Therefore the interval between two powers is equal to $10 \log_{10}\left(\frac{W_1}{W_0}\right)$dB.

The corresponding formulae with reference to voltages and currents are

(1) $20 \log_{10}\left(\frac{V_1}{V_0}\right)$ dB and

(2) $20 \log_{10}\left(\frac{I_1}{I_0}\right)$ dB

Neper: The power interval N (in nepers) between W_1 and W_0 is given by

$$N = \frac{1}{2} \log_e \left(\frac{W_1}{W_0}\right)$$

The corresponding formulae with voltages and currents are

$$N = \log_e \left(\frac{V_1}{V_e}\right) = \log_e \left(\frac{I_1}{I_0}\right)$$

1 neper (N) = 8·686 dB and 1 dB=0·115 13 neper.

Intensity (J) of a sound wave in a specified direction at a point is the sound energy transmitted per second in the specified direction through unit area normal to this direction at the point. Unit : $Js^{-1}\ m^{-2}$ or Wm^{-2}.

For a sinusoidal plane or spherical wave the intensity is proportional to the mean square pressure exerted on an area (at the point) at right angles to the given direction. Hence the interval between the two intensities is given by $10 \log_{10} \left(\frac{J_1}{J_0}\right)$ dB or $20 \log_{10} \left(\frac{P_1}{P_0}\right)$ dB, where P_1 and P_0 are the (rms) pressures corresponding to the intensities J_1, and J_0. The arbitrary standard level (J_0) against which sound intensities are measured is 10^{-12} Wm^{-2}, the subjective threshold intensity of hearing corresponding to a root mean square pressure P_0 of $2{\cdot}04 \times 10^{-5}$ Pa.

Loudness of a sound is the magnitude of the auditory sensation produced by the sound. It is a *subjective* quantity because it depends upon the observer. It is not merely a function of the intensity, as it varies with frequency and composition of the note being heard.

Loudness level of a given sound is obtained by matching it with that of a standard pure tone whose frequency is 1 000 Hz. The standard source is adjusted till its loudness becomes equal to that of the sound as judged by a normal observer. If now the intensity or power level of the standard source is n decibels above the theshold value (10^{-12} Wm^{-2}), the loudness of the sound is said to have a level of n *phons*.

Thus the loudness level of sound in phons is numerically equal to the sound intensity level or sound pressure level of an equally loud 1 000 Hz pure tone in dB. Unit : Phon

Loudness: One Sone is the loudness of sound whose loudness level is 40 phons: Unit : Sone

$$S = 2^{(p-40)/10}$$

Reverberation time of an enclosure for sound of a given frequency is the time required for the sound intensity in the enclosure, initially in a steady state, to decrease after the source is stopped to one millionth (10^{-6}) of its initial value, i.e., by 60 dB. Unit : Second.

Absorption Coefficient: The acoustical absorption coefficient of a surface is the ratio of the sound energy absorbed to the total sound energy incident on it. An ideal absorber is one from which no sound is reflected or scattered like an *open window* which has an absorption coefficient of unity.

Sabine's Formula: For an auditorium whose walls etc., consist of areas A_1, A_2 etc., of absorption coefficients α_1, α_2 ...... etc., the reverberation time is given by

$$t = \frac{0{\cdot}16\,V}{\Sigma\,\alpha\,A}$$

where

$\Sigma\,\alpha\,A = \alpha_1 A_1 + \alpha_2 A_2 + \alpha_3 A_3 + \ldots$ etc., and
V = volume of the auditorium.

H. Nuclear

Law of radioactive transformation (decay)

In a given specimen the rate of decay (transform) at any instant is proportional to the number of radioactive atoms of the isotope under consideration present at that instant. Thus if N is the number of the particular atom (nuclei) present at any time t, the transformation rate is given by

$$\frac{dN}{dt} = -\lambda N$$

where λ is called the transformation (decay) constant of the particular type of nuclide. On integration from any arbitrary zero time we get

$$N = N_0\,e^{-\lambda t}$$

where N_0 is the number of the radioactive nuclide of the specified kind at zero time.

Half life

It is the time required for the number of radioactive nuclei of a given kind to decay to half its value.

The half life $$T_{\frac{1}{2}} = \frac{\log_e 2}{\lambda} = \frac{0{\cdot}6931}{\lambda}$$

Mean life

The mean life is equal to the average life expectancy of the nuclei present at any instant

The mean life $$t_m = \frac{1}{\lambda}$$

Activity

The number of disintegrations which a given amount of material undergoes in a given time interval is defined as the activity.

9. Definitions of SI Units (Contd.)

Curie (Ci)

The unit of activity is the *curie*. It is the quantity of any radioactive species decaying at a rate of $3{\cdot}7 \times 10^{10}$ disintegrations per second. The milli curie (mCi) and micro curie (μCi) are also used. $1\ \mathrm{Ci}=3{\cdot}7\times10^{10}\mathrm{s}^{-1}$

Rutherford (unit of activity)

It is the amount of radioactive matter which undergoes 10^6 disintegrations per second

$$1\ \text{curie} = 37\ 000\ \text{rutherfords}$$

Roentgen

The roentgen (R) is the dose of X or gamma radiation such that an associated corpuscular emission per 1·293 mg of air produces in air ions carrying $\left(\frac{1}{3\times10^9}\right)$ coulombs of electricity of either sign 1. $\mathrm{R}=2{\cdot}58\times10^{-4}$/Ckg

(The mass of one cubic centimetre of air at 0°C and standard atmosphere is 1·293 mg).

$$\begin{aligned}\text{Roentgen (R)} &= 2{\cdot}08 \times 10^9\text{ion pair/cm}^3\text{ air at s.p.t.}\\ &= 1{\cdot}61 \times 10^{12}\text{ion pair/g of dry air}\\ &= 83{\cdot}8 \times 10^{-7}\text{ joules/g of dry air}\end{aligned}$$

(based on 32·5 eV/ion pair)

Dose rates are measured in units of roentgen hour^{-1} or milliroentgen hour^{-1}

Rad: The rad is a dose of ionized radiation at which 1 g of irradiated material absorbs 100×10^{-7} joules of energy. $1\ \text{rad} = 10^{-2}$ J/kg

Rep*: The rep is the dose of ionizing radiation at which the energy absorbed by a substance is equal to the loss in energy during ionization caused by 1 R of X or gamma radiation.

In physical reactions 1 rep of corpuscular radiation is equal to 1 R of electromagnetic radiation.

(*Roentgen equivalent physical).

PART II

Physical and Chemical Data

I. Physical Constants

(The figure in brackets following the final digit is the estimated uncertainty in the last digit)

Quantity	Symbol	Value	Prefix	SI unit
Speed of light in vacuum	c	2·997 925 (1)	10^{8}	ms^{-1}
Gravitational constant	G	6·673 (3)	10^{-11}	$Nm^{2} kg^{-2}$
Avogadro constant	N_{A}	6·022 17 (4)	10^{23}	mol^{-1}
Boltzman constant	k	1·380 62 (6)	10^{-23}	JK^{-1}
Gas constant	R	8·314 3 (3)	10^{0}	$JK^{-1} mol^{-1}$
Volume of mole of ideal gas at s. t. p.	V_{0}	2·241 36 (30)	10^{-2}	$m^{3} mol^{-1}$
Faraday constant	F	9·648 67 (5)	10^{4}	$C mol^{-1}$
Unified atomic mass unit	u	1·660 43	10^{-27}	kg
Planck constant	h	6·626 20 (5)	10^{-34}	Js
	$h/2_{\pi}$	1·054 592 (8)	10^{-34}	Js
Electron charge	e	1·602 192 (7)	10^{-19}	C
Electron rest mas	m_{e}	9·109 56 (5)	10^{-31}	kg
Proton rest mass	m_{p}	1·672 614 (11)	10^{-27}	kg
Neutron rest mass	m_{n}	1·674 920 (11)	10^{-27}	kg
Electron charge - mass ratio	e/m_{e}	1·758 803 (5)	10^{11}	$C kg^{-1}$
Stefan-Boltzmann constant	σ	5·669 6 (9)	10^{-8}	$Wm^{-2} K^{-4}$
First radiation constant	$2_{\pi}hc^{2}$	3·741 844	10^{-16}	Wm^{2}
Second radiation constant	h_{c}/k	1·438 833	10^{-2}	mK
Rydberg constant	R_{∞}	1·097 373 1 (1)	10^{7}	m^{-1}
Fine structure constant	α	7·297 351 (11)	10^{-3}	
	α^{-1}	1·370 360 (2)	10^{2}	
Bohr radius	a_{0}	5·291 772 (8)	10^{-11}	m
Classical electron radius	r_{e}	2·817 939 (13)	10^{-15}	m
Compton wave-length of electron	λ_{c}	2·426 310 (7)	10^{-12}	m
Compton wave-length of proton	λ_{c}, ρ	1·321 441 (9)	10^{-15}	m

1. Physical Constants (Contd.)

Quantity	Symbol	Value	Prefix	SI unit
Compton wave-length of neutron	$\lambda_{c,n}$	1·319 621 7	10^{-15}	m
lectron magnetic moment	μ_e	9·284 851	10^{-24}	$J\,T^{-1}$
Proton magnetic moment	μ_p	1·410 620 3	10^{-26}	$J\,T^{-1}$
Bohr magneton	μ_B	9·274 10 (6)	10^{-24}	$J\,T^{-1}$
Nuclear magneton	μ_n	5·050 95 (5)	10^{-27}	$J\,T^{-1}$
Gyromagnetic ratio of protons in H_2O	γ'_p	2·675 127 (8)	10^{8}	$rad\,s^{-1}\,T^{-1}$
	$\frac{\gamma'_p}{2\pi}$	4·257 597	10^{7}	$Hz\,T^{-1}$
Gyromagnetic ratio of Eprotons in H_2O corrected for diamagnetism of H_2O	γ_p	2·675 197 (8)	10^{8}	$rad\,s^{-1}\,T^{-1}$
	$\frac{\gamma_p}{2\pi}$	4·257 707	10^{7}	$Hz\,T^{-1}$
Magnetic flux quantum	Φ_o	2·067 853 8	10^{-15}	Wb
Quantum of circulation	$h/2\,m_e$	3·636 947	10^{-4}	$Js\,kg^{-1}$
Permeability of free space	μ_o	4π	10^{-7}	$H\,m^{-1}$
Permittivity of free space	ϵ_o	8·854 19 (1)	10^{-12}	$F\,m^{-1}$
Impedance of free space	Z_o	3·767 304 (1)	10^{2}	ohm
Electron rest energy	$m_e\,c^2$	8·187 26 (6)	10^{-14}	J
Proton rest energy	$m_p\,c^2$	1·503 271 (15)	10^{-10}	J
Proton charge-mass ratio	e/m_p	9·578 97 (11)	10^{7}	Ckg^{-1}
Neutron rest energy	$m_n\,c^2$	1·505 343 (15)	10^{-10}	J
Zeeman splitting constant	μ_c/hc	4·668 60 (7)	10^{1}	$m^{-1}\,T^{-1}$
Loschmidt's constant (molecules in unit volume of gas at s.t.p.)	$\frac{N_A}{V_o}$	2·687 0	10^{25}	$m^{-3}\,atm^{-1}$
Impedance of free space	Z_o	3·767 304 (1)	10^{2}	ohm

2. Astronomical Data

Time

1 mean solar day	=86 400 mean solar seconds
1 sidereal day (period of earth's axial rotation)	=86 164 mean solar seconds
1 mean lunar month (new moon to new moon)	=29·531 mean solar days
1 tropical year (equinox to equinox)	=365·242 mean solar days
1 sidereal year (fixed star to fixed star)	=365·256 mean solar days

Distance

1 Astronomical Unit (AU) (mean sun-to-earth distance)	$=1{\cdot}496\times10^{8}$ km
1 Parsec (pc)	$=3{\cdot}085\,6\times10^{13}$ km
1 Light second (ls)	$=2{\cdot}998\times10^{5}$ km
1 Light year (ly)	$=9{\cdot}460\,5\times10^{12}$ km

The Sun

Radius	$=6{\cdot}960\times10^{5}$ km
Surface area	$=6{\cdot}087\times10^{18}$ m^{2}
Volume	$=1{\cdot}412\times10^{27}$ m^{3}
Mass	$=1{\cdot}99\times10^{30}$ kg
Rate of energy production	$=3{\cdot}90\times10^{26}$ Js^{-1}
Moment of inertia	$=6{\cdot}0\times10^{46}$ kgm^{2}
*Period of rotation with respect to earth	=27·28 days
*Sidereal period of rotation (*latitude 16°)	=25·38 days

The Moon

Radius	=1 738 km
Surface area	$=3{\cdot}796\times10^{13}$ m^{2}
Volume	$=2{\cdot}199\times10^{19}$ m^{3}
Mass	$=7{\cdot}349\times10^{22}$ kg $=\dfrac{1}{81{\cdot}4}\times$ (mass of earth)
Mean distance from the earth	$=3{\cdot}844\times10^{5}$ km
Moment of inertia	$=8{\cdot}8\times10^{28}$ kg m^{2}
Sidereal period of moon about earth	=27·32 mean solar days

3. The Solar System

R = equatorial radius
M = mass
g = acceleration of gravity on surface
ρ = mean mass density
d = mean distance from sun

} given relative to earth = 1

ε = eccentricity of orbit
θ = inclination to ecliptic
N = number of satellites (known)
T_S = siderial period or time to move once round the orbit
T_R = period of rotation about axis
V_e = escape velocity

Planet	$R/R_\oplus$	$M/M_\oplus$	$g/g_\oplus$	d/km $\times 10^6$	ρ/kgm^{-3}	ε	$\theta/_o$	N	T_S	T_R	V_e/kms^{-1}
Sun	109.1	332 800	27.94	—	1 409	—	—	—		25.38 d	618
Mercury	0.38	0.055	0.38	57.91	5 420	0.205 6	7.004	0	87.97 d	58.7 d	4.3
Venus	0.95	0.814	0.89	108.2	5 250	0.006 8	3.394	0	224.7 d	243 d	10.4
Earth	1.00	1.00	1.00	149.6	5 510	0.016 7	0	1	365.3 d	23.93 h	11.2
Moon	0.27	0.013	0.17	149.6	3 340	0.055	5.144	—	27.32 d	27.32 d	2.38
Mars	0.53	0.107	0.39	227.9	3 960	0.093 4	1.850	2	687 d	24.6 h	5.04
Jupiter	11.19	317.7	2.54	778.3	1 330	0.048 1	1.306	12	11.86 y	9.9 h	60.25
Saturn	9.47	95.08	1.06	1 427.0	680	0.053 3	2.489	10	29.46 y	10.2 h	36.7
Uranus	3.7	14.53	1.06	2 869.0	1 600	0.050 7	0.773	5	84.02 y	10.7 h	22.4
Neptune	3.5	17.14	1.41	4 498.0	1 650	0.004 0	1.773	2	168.4 y	15.8 h	25.6
Pluto	0.47	0.08 36	0.41	5 900.0	3 000	0.253 3	17.14	0	248 y	6.3 d	—

Note: The planetary orbits are subject to both secular and periodic perturbations.
Periods are measured in hours (h), days (d) or years (y)

4. Terrestrial and Geodetic Data

(a) The Earth

Polar radius = 6 356.8 km
Equatorial radius = 6 378.2 km
Mean radius = 6 371 km
Surface area = 5.101×10^{14} m
Volume = 1.083×10^{21} m^3
Mass = 5.977×10^{24} kg
Mean density = 5 517 kg m^{-3}
Mean distance to the sun (AU) = $1{\cdot}496 \times 10^8$ km
Gravity at surface (standard) = 9·806 65 ms^{-2}
Moment of inertia about axis of rotation = 8.04×10^{37} kg m^2
Escape velocity at surface = 11.2 kms^{-1}
Rotational velocity at equator = 465 ms^{-1}
Mean velocity in its orbit about the sun = 29.78 kms^{-1}
Solar constant (solar energy incident on unit area normal to the sun's rays at the earth's mean distance, per unit time) = 1 400 Jm^{-2} s^{-1}
1° of latitude at equator = 110.5 km
1° of latitude at poles = 111.7 km
1° of longitude at equator = 111.3 km
Inclination of equator to ecliptic (i.e. mean plane of earth's orbit) = 23° 27′
Period of rotation with respect to the fixed stars = 23h 56m 4s (mean solar time
Rate of rotation 0.000 072 921 151 radians per mean solar second.
Land area = 148.8×10^6 km^2
Ocean area = 361.3×10^6 km^2

(b) Composition of the Earth's Atmosphere

(Parts in 10^6 of dry air by volume)

N_2	780 900	CH_4	1·5
O_2	209 500	Kr	1·14
A	9 300	N_2O	0·5
CO_2*	300	H_2	0·5
Ne	18	O_3	0·4
He	5·2	Xe	0·086

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* Near industrial areas this varies to some extent.

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(c) Principal Elements in Earth's Crust (% by mass)

Oxygen	49·13	Sodium	2·40
Silicon	26·00	Potassium	2·35
Aluminium	7·45	Magnesium	2·35
Iron	4·20	Hydrogen	1·00
Calcium	3·25	All others	1·87

(d) Principal Elements in the Hydrosphere (% by mass)

Oxygen	85·89	Sodium	1·06
Hydrogen	10·89	All others	0·33
Chlorine	1·90		

(e)

Height of Troposphere	12-15 km
Height of Stratosphere	about 15-40 km
Height of Ozone layer	about 40 km
Height of Heaviside layer (E)	about 100-150 km
Height of Appleton layer (F)	about 200-350 km

(f) Standard Times (referred to Greenwich time)

Time		Country	Time		Country
Noon at Greenwich	Clock ahead of Greenwich	Great Britain, Ireland, France, Belgium, Spain, Portugal	5.30 p. m.	Clock ahead	India, Ceylon
			7 p. m.		Malaya
			8 p. m.—10 p.m.		Australia
			9 p. m.		Japan, Korea
12.20 p. m		Holland	11.30 p. m.		New Zealand
			12 p. m.		Fiji
1 p. m.		Austria, Denmark, Germany, Italy, Scandinavia, Switzerland, Poland, Yugoslavia, Hungary, Czechoslovakia, Nigeria	11 a.m.	Clock behind	Iceland
			9 a.m.—7 a.m.		Brazil
			8 a.m.		Argentine, Trinidad
2 p. m.		British South Africa, Egypt, Turkey, Greece, Finland, Bulgaria, Palestine, Soviet Russia (2 p. m. and 3 p. m.)	8 a..m.—4 a.m.		U.S.A., and Canada
			7 a. m.		Jamaica, Chili, Cuba, Peru, Panama
3 p. m		Kenya, Tanganyika, Somaliland, Iraq			

5. (a) Acceleration of Gravity (g)

Standard value for g = 9·806 65 $\mathrm{ms^{-2}}$

At any latitutde λ and height h (metres) above sea level

$$g/\mathrm{ms^{-2}} = 9{\cdot}806\,16 - 0{\cdot}025\,928 \cos 2\lambda + 0{\cdot}000\,069 \cos^2 2\lambda - 0{\cdot}000\,003\, h$$

Acceleration of Gravity at Different Latitudes (h = o).

Latitude $\lambda/°$	$g/\mathrm{ms^{-2}}$	Latitude $\lambda/°$	$g/\mathrm{ms^{-2}}$	Latitude $\lambda/°$	$g/\mathrm{ms^{-2}}$
0	9·780 35	35	9·797 32	70	9·826 00
5	9·780 74	40	9·801 67	75	9·828 59
10	9·781 90	45	9·806 15	80	9·830 51
15	9·783 80	50	9·810 65	85	9·831 68
20	9·786 38	55	9·815 01	90	9·832 07
25	9·789 55	60	9·819 08		
30	9·793 24	65	9·822 80		

Correction for altitude :. 0·000 003 $\mathrm{ms^{-2}/m}$ for altitude in metres.

5. (b) Acceleration of Gravity at Some Stations

Station	Latitude λ	Height h/m	Acceleration of gravity ($g/\mathrm{ms^{-2}}$)
1. Agra	27°10′	169	9·790 60
2. Bombay	18°54′	10	9·786 30
3. Calcutta	22°35′	6	9·788 20
4. Capetown	33°56′s	11	9·796 60
5. Colombo	6°54′	—	9·781 11
6. Dehra Dun	30°20′	682	9·790 70
7. Edinburgh	55°57′	—	9·815 80
8. Equator	0°0′	—	9·780 30
9. Jabalpur	23°9′	447	9·787 20
10. Leningrad	59°55′	3	9·819 29
11. London (Teddington)	51°25′	48	9·811 83
12. Madras	13°5′	6	9·782 81
13. New York	40°40′	38	9·802 67
14. North Pole	90°0′	—	9·832 20
15. Paris	48°52′	61	9·809 43
16. Sydney	33°55′s	—	9·796 80
17. Tokyo	35°40′	18	9·798 01
18. Yercaud	11°47′	1 369	9·779 10

6. The Periodic Table

Periodic Table (incorporating the new atomic-weight values).

1 H 1.0080 b,d																	2 He 4.00260 b,c
3 Li 6.941 c,d,e	4 Be 9.01218 a											5 B 10.81 c,d,e	6 C 12.011 b,d	7 N 14.0067 b,c	8 O 15.9994 b,c,d	9 F 18.9984 a	10 Ne 20.179 c
11 Na 22.9898 a	12 Mg 24.305 c											13 Al 26.9815 a	14 Si 28.086 d	15 P 30.9738 a	16 S 32.06 d	17 Cl 35.453 c	18 Ar 39.948 b,c,d,g
19 K 39.102	20 Ca 40.08	21 Sc 44.9559 a	22 Ti 47.90	23 V 50.9414 b,c	24 Cr 51.996 c	25 Mn 54.9380 a	26 Fe 55.847	27 Co 58.9332 a	28 Ni 58.71	29 Cu 63.546 c,d	30 Zn 65.37	31 Ga 69.72	32 Ge 72.59	33 As 74.9216 a	34 Se 78.96	35 Br 79.904 c	36 Kr 83.80
37 Rb 85.4678 c	38 Sr 87.62 g	39 Y 88.9059 a	40 Zr 91.22	41 Nb 92.9064 a	42 Mo 95.94	43 Tc 98.9062 f	44 Ru 101.07	45 Rh 102.9055 a	46 Pd 106.4	47 Ag 107.868 c	48 Cd 112.40	49 In 114.82	50 Sn 118.69	51 Sb 121.75	52 Te 127.60	53 I 126.9045 a	54 Xe 131.30
55 Cs 132.9055 a	56 Ba 137.34	57 La 138.9055 b	72 Hf 178.49	73 Ta 180.9479 b	74 W 183.85	75 Re 186.2	76 Os 190.2	77 Ir 192.22	78 Pt 195.09	79 Au 196.9665 a	80 Hg 200.59	81 Tl 204.37	82 Pb 207.2 d,g	83 Bi 208.9806 a	84 Po —	85 At —	86 Rn —
87 Fr —	88 Ra 226.0254 a,f,g	89 Ac —															
				58 Ce 140.12	59 Pr 140.9077 a	60 Nd 144.24	61 Pm —	62 Sm 150.4	63 Eu 151.96	64 Gd 157.25	65 Tb 158.9254 a	66 Dy 162.50	67 Ho 164.9303 a	68 Er 167.26	69 Tm 168.9342 a	70 Yb 173.04	71 Lu 174.97
				90 Th 232.0381 a,f	91 Pa 231.0359 a,f	92 U 238.029 b,c,e	93 Np 237.0482 b,f	94 Pu —	95 Am —	96 Cm —	97 Bk —	98 Cf —	99 Es —	100 Fm —	101 Md —	102 No —	103 Lr —

Footnotes

a Mononuclidic element.

b Element with one predominant isotope (about 99–100 per cent abundance).

c Element for which the atomic weight is based on calibrated measurements.

d Element for which variation in isotopic abundance in terrestrial samples limits the precision of the atomic weight given.

e Element for which users are cautioned against the possibility of large variations in atomic weight due to inadvertent or undisclosed artificial isotopic separation in commercially available materials.

f Most commonly available long-lived isotope;

g In some geological specimens this element has a highly anomalous isotopic composition corresponding to an atomic weight significantly different from that given.

7. Electronic Configuration

Layer		K	L		M			N	
n		1	2		3			4	
l		0	0	1	0	1	2	0	1
Subgroup		1s	2s	2p	3s	3p	3d	4s	4p
1	H	1							
2	He	2							
3	Li	2	1						
4	Be	2	2						
5	B	2	2	1					
6	C	2	2	2					
7	N	2	2	3					
8	O	2	2	4					
9	F	2	2	5					
10	Ne	2	2	6					
11	Na	2	2	6	1				
12	Mg	2	2	6	2				
13	Al	2	2	6	2	1			
14	Si	2	2	6	2	2			
15	P	2	2	6	2	3			
16	S	2	2	6	2	4			
17	Cl	2	2	6	2	5			
18	Ar	2	2	6	2	6			
19	K	2	2	6	2	6		1	
20	Ca	2	2	6	2	6		2	
21	Sc	2	2	6	2	6	1	2	
22	Ti	2	2	6	2	6	2	2	
23	V	2	2	6	2	6	3	2	
24	Cr	2	2	6	2	6	5	1	
25	Mn	2	2	6	2	6	5	2	
26	Fe	2	2	6	2	6	6	2	
27	Co	2	2	6	2	6	7	2	
28	Ni	2	2	6	2	6	8	2	
29	Cu	2	2	6	2	6	10	1	
30	Zn	2	2	6	2	6	10	2	
31	Ga	2	2	6	2	6	10	2	1
32	Ge	2	2	6	2	6	10	2	2
33	As	2	2	6	2	6	10	2	3
34	Se	2	2	6	2	6	10	2	4
35	Br	2	2	6	2	6	10	2	5
36	Kr	2	2	6	2	6	10	2	6

Layer		K	L	M	N				O			P
n		1	2	3	4				5			6
l					0	1	2	3	0	1	2	0
Subgroup					4s	4p	4d	4f	5s	5p	5d	6s
37	Rb	2	8	18	2	6			1			
38	Sr	2	8	18	2	6			2			
39	Y	2	8	18	2	6	1		2			
40	Zr	2	8	18	2	6	2		2			
41	Nb	2	8	18	2	6	4		1			
42	Mo	2	8	18	2	6	5		1			
43	Tc	2	8	18	2	6	5		2			
44	Ru	2	8	18	2	6	7		1			
45	Rh	2	8	18	2	6	8		1			
46	Pd	2	8	18	2	6	10		0			
47	Ag	2	8	18	2	6	10		1			
48	Cd	2	8	18	2	6	10		2			
49	In	2	8	18	2	6	10		2	1		
50	Sn	2	8	18	2	6	10		2	2		
51	Sb	2	8	18	2	6	10		2	3		
52	Te	2	8	18	2	6	10		2	4		
53	I	2	8	18	2	6	10		2	5		
54	Xe	2	8	18	2	6	10		2	6		
55	Cs	2	8	18	2	6	10		2	6		1
56	Ba	2	8	18	2	6	10		2	6		2
57	La	2	8	18	2	6	10		2	6	1	2
58	Ce	2	8	18	2	6	10	2	2	6		2
59	Pr	2	8	18	2	6	10	3	2	6		2
60	Nd	2	8	18	2	6	10	4	2	6		2
61	Pm	2	8	18	2	6	10	5	2	6		2
62	Sm	2	8	18	2	6	10	6	2	6		2
63	Eu	2	8	18	2	6	10	7	2	6		2
64	Gd	2	8	18	2	6	10	7	2	6	1	2
65	Tb	2	8	18	2	6	10	9	2	6		2
66	Dy	2	8	18	2	6	10	10	2	6		2
67	Ho	2	8	18	2	6	10	11	2	6		2
68	Er	2	8	18	2	6	10	12	2	6		2
69	Tm	2	8	18	2	6	10	13	2	6		2
70	Yb	2	8	18	2	6	10	14	2	6		2
71	Lu	2	8	18	2	6	10	14	2	6	1	

Layer		K	L	M	N	O				P			Q
n		1	2	3	4	5				6			7
l						0	1	2	3	0	1	2	0
Subgroup						5s	5p	5d	5f	6s	6p	6d	7s
72	Hf	2	8	18	32	2	6	2		2			
73	Ta	2	8	18	32	2	6	3		2			
74	W	2	8	18	32	2	6	4		2			
75	Re	2	8	18	32	2	6	5		2			
76	Os	2	8	18	32	2	6	6		2			
77	Ir	2	8	18	32	2	6	7		2			
78	Pt	2	8	18	32	2	6	9		1			
79	Au	2	8	18	32	2	6	10		1			
80	Hg	2	8	18	32	2	6	10		2			
81	Tl	2	8	18	32	2	6	10		2	1		
82	Pb	2	8	18	32	2	6	10		2	2		
83	Bi	2	8	18	32	2	6	10		2	3		
84	Po	2	8	18	32	2	6	10		2	4		
85	At	2	8	18	32	2	6	10		2	5		
86	Rn	2	8	18	32	2	6	10		2	6		
87	Fr	2	8	18	32	2	6	10		2	6		2
88	Ra	2	8	18	32	2	6	10		2	6		2
89	Ac	2	8	18	32	2	6	10		2	6	1	2
90	Th	2	8	18	32	2	6	10		2	6	2	2
91	Pa	2	8	18	32	2	6	10	2	2	6	1	2
92	U	2	8	18	32	2	6	10	3	2	6	1	2
93	Np	2	8	18	32	2	6	10	5	2	6		2
94	Pu	2	8	18	32	2	6	10	6	2	6		2
95	Am	2	8	18	32	2	6	10	7	2	6		2
96	Cm	2	8	18	32	2	6	10	7	2	6	1	2
97	Bk	2	8	18	32	2	6	10	9	2	6		2
98	Cf	2	8	18	32	2	6	10	10	2	6		2
99	Es	2	8	18	32	2	6	10	11	2	6		2
100	Fm	2	8	18	32	2	6	10	12	2	6		2
101	Md	2	8	18	32	2	6	10	13	2	6		2
102	No	2	8	18	32	2	6	10	14	2	6		2
103	Lw	2	8	18	32	2	6	10	14	2	6	1	2

8. Properties of the Elements (Contd.)

Symbol	Element	Atomic Number Z	Relative atomic mass M/g mol^{-1}	Principal oxidation numbers	Ionization energies E_i/eV	Density ρ/kg m^{-3} $\times 10^3$	Melting point T_m/K	Boiling point T_b/K	Stable isotopes*
Cs	Caesium	55	132·9	1+	3·9	1·87	302·0	960	**133**
Ca	Calcium	20	40·08	2+	6·1	1·54	1 120	1 760	**40**, 42, 43, 44, 46
Cf	Californium	98	251	—	—	—		—	—
C	Carbon	6	12·01	4+ 4−	11·3	2·3	3 800	5 100	**12**, 13
Ce	Cerium	58	140·12.	3+ 4+	5·5	6·8	1 070	3 740	136, 138, **140**, 142
Cl	Chlorine	17	3 ·45	1− 5+	13·0	0·003 21 (273 K)	172·1	238·8	**35, 37**
Cr	Chromium	24	52·0	3+ 6+	6·8	7·2	2 160	2 755	50, **52**, 53, 54
Co	Cobalt	27	58·93	2+ 3+	7·9	8·9	1 765	3 170	**59**
Cu	Copper	29	63·54	1+ 2+	7·7	8·93	1 356	2 868	**63, 65**
Cm	Curium	96	247	—	—	—	1 613	—	—
Dy	Dysprosium	66	162·5	3+	5·9	8·50	1 680	2 900	156, 158, 160, 161, **162, 163, 164**
Es	Einstenium	99	254	—	—	—	—	—	—
Er	Erbium	68	167·26	3+	6·10	9·00	1 770	3 200	162, 164, **166, 167, 168**, 170

8. Properties of the Elements

The atomic masses in this table are based on 12 C = 12 scale

Symbol	Element	Atomic Number Z	Relative atomic mass M/g mol^{-1}	Principal oxidation numbers	Ionization energies $E/_eV$	Density ρ/kg m^{-3} $\times 10^3$	Melting point T_m/K	Boiling point T_b/K	Stable isotopes*
Ac	Actinium	89	227·0	3+	6·9	10·1	1 320	3 470	—
Al	Aluminium	13	26·98	3+	6·0	2·7	933·1	2 740	**27**
Am	Americum	95	243	—	—	—	1 267	2 880	—
Sb	Antimony	51	121·75	3+ 5+	8·6	6·7	903·7	1 650	**121, 123**
Ar	Argon	18	39·95	0	15·76	0·001 66	83·7	87·4	36, 38, **40**
As	Arsenic	33	74·92	3+ 5+	9·8	5·73	1 090	886 (sublimates)	**75**
At	Astatine	85	210	7+	9·5	—	520	623	—
Ba	Barium	56	137·34	2+	5·2	3·6	1 000	1 910	130, 132, 134, 135 136, 137, **138**
Bk	Berkelium	97	247	–	—	—	—	—	—
Be	Beryllium	4	9·01	2+	9·3	1·8	1 550	3 240	**9**
Bi	Bismuth	83	208·98	3+ 5+	7·3	9·8	544	1 830	**209**
B	Boron	5	10·81	3+	8·3	2·5	2 600	2 820	10, **11**
Br	Bromine	35	79·91	1− 5+	11·8	3·1	266·0	332·0	**79, 81**
Cd	Cadmium	48	112·4	2+	9·0	8·65	594·1	1 038	106, 108, 110, 111 **112**, 113, **114**, 116

* Isotopes in bold print form more than 20%.

8. Properties of the Elements (Contd.)

Symbol	Element	Atomic number Z	Relative atomic mass $M/g\ mol^{-1}$	Principal oxidation numbers	Ionization energies E_i/V	Density $\rho/kg\ m^{-3}$ $\times 10^3$	Melting point T_m/K	Boiling point T_b/K	Stable isotopes*
Fe	Iron	26	58·85	2+ 3+	7·9	7·87	1 808	3 300	54, **56**, 57, 58
Kr	Krypton	36	83·80	0	14·0	0·003 49	116·5	120·8	78, 80, 82, **84**, 86
La	Lanthanum	57	138·91	1+ 3+	5·6	6·15	1 190	3 740	138, **139**
Lr	Lawrentium	103	257	—	—	—	—	—	—
Pb	Lead	82	207·19	2+ 4+	7·4	11·34	600·4	2 017	204, **206**, **207**, **208**
Li	Lithium	3	6·94	1+	5·4	0·534	452	1 590	6, **7**
Lu	Lutetium	71	174·97	3+	5·4	9·8	1 925	3 600	**175**, 176
Mg	Magnesium	12	24·31	1+ 2+	7·6	1·741	924	1 380	**24**, 25, 26
Ma	Manganese	25	54·94	2+ 3+	7·4	7·44	1 517	2 370	**55**
Md	Mandelevium	101	256	—	—	—	—	—	—
Hg	Mercury	80	200·59	1+ 2+	10·4	13·59	243·3	630·	196, 198, 199, **200** 201, **202** 204
Mo	Molybdenum	42	95·94	4+ 6+	7·1	10·20	2 880	5 830	92, 94, 96, 97, **98**
Nd	Neodymium	60	144·24	3+	5·5	6·96	1 297	3 300	**142**, 143, **144**, 145, 146, 148, 150
Ne	Neon	10	20·18	0	21·6	0·000 839	24·5	27·2	**20**, 21, 22
Np	Neptunium	93	237·05	—	—	—	913	4 175	—

8. Properties of the Elements (Contd.)

Symbol	Element	Atomic Number Z	Relative atomic mass $M/g\ mol^{-1}$	Principal oxidation numbers	Ionization energies E/eV	Density $\rho/kg\ m^{-3}$ $\times 10^3$	Melting point T_m/K	Boiling point T_b/K	Stable isotopes *
Ew	Europium	63	151·96	3+ 2+	5·7	5·20	1 100	1 712	151, 153
Fm	Fermium	100	257	–	–	–	–	–	—
F	Fluorine	9	19·00	1– 7+	17·4	0·0017 (273 K)	53·5	85·01	19
Fr	Francium	87	223	1+	4·0	–	303	920	—
Gd	Gadolinium	64	157·25	3+	6·1	7·9	1 585	3 000	152, 154, 155, 156, 157, 158, 160
Ga	Gallium	31	69·72	1+ 3+	6·0	5·95	302·9	2 676	69, 71
Ge	Germanium	32	72·59	△+	7·9	5·40	1 211	3 100	70, 72, 73 74, 76
Au	Gold	79	169·97	1+ 3+	9·20	19·30	1 336	3 239	197
Hf	Hafnium	72	178·49	4+	7·0	13·30	2 420	5 700	174, 176, 177, 178, 179, 180
He	Helium	2	4·003	0	24·6	0·000 146	0·95	4·21	3, 4
Ho	Holmium	67	164·93	3+	6·0	8·81	1 734	2 900	165
H	Hydrogen	1	1·00 797	1–	13·6	0·000 089 87 (273 K)	14·01	20·65	1, 2
In	Indium	49	141·82	3+	5·79	7·31	429·8	2 300	113, 115
I	Iodine	53	126·9	1–	10·5	4·94	386·6	457·4	127
Ir	Iridium	77	192·2	4+	9·1	22·42	2 716	4 800	191, 193

8. Properties of the Elements (Contd.)

Symbol	Element	Atomic Number Z	Relative atomic mass M/g mol^{-1}	Principal oxidation number	Ionization energies E/e V	Density ρ/kg m^{-3} $\times 10^3$	Melting point T_m/K	Boiling point T_b/K	Stable isotopes*
Ra	Radium	88	226	2+	5·3	5·0	970	1 410	—
Rn	Radon	86	222	0	10·7	0·009 73 (273 K)	202	211·3	—
Re	Rhedium	75	186·2	4+	7·9	20·5	3·450	5 900	**185, 187**
Rh	Rhodium	45	102·91	3+	7·5	12·44	2 230	4 000	**103**
Ru	Rubidium	37	85·47	1+	4·2	1·53	312	961	85, 87
Ru	Ruthenium	44	101·07	4+	7·4	12·4	2 520	4 200	96, 98, 99, 100, 101, **102**, 104
Sm	Samarium	62	150·35	3+	5·6	7·5	1 350	2 200	144, 147, 148, 149 150, **152, 154**
Sc	Scandium	21	44·96	3+	6·5	3·0	1 810	3 000	**45**
Se	Selenium	34	78·96	2−	9·8	4·81	490	960	74, 76, 77, **78, 80**, 82
Si	Silicon	14	28·09	4+ 4−	8·2	2·3	1 680	2 630	**28**, 29, 30
Ag	Silver	47	107·87	1+	7·6	10·5	1 230	2 490	**107, 109**
Na	Sodium	11	22·99	1+	5·1	0·97	370	1 170	**23**
Sr	Strontium	38	87·62	2+	5·7	2·6	1 040	1 660	84, 86, 87, **88**
S	Sulphur	16	32·06	2− 4+	10·4	2·07	386	720	**32**, 33, **34**, 36
Ta	Tantalum	73	180·95	5+	7·9	16·	63 270	5 700	**181**
Tc	Technetium	43	99	7+	7·3	11·4	2 500	4 900	—
Te	Tellurium	52	127·60	2−	9·0	6·24	723	1 260	120, 122, 123, 124, 125, 126, **128, 130**

8. Properties of the Elements (Contd.)

Symbol	Element	Atomic Number Z	Relative atomic mass M/g mol^{-1}	Principal oxidation number	Ionization energies $E/_e$ V	Density ρ/kg m^{-3} ×10^3	Melting point T_m/K	Boiling point T_b/k	Stable isotopes*
Ni	Nickel	28	58·71	2+ 3+	7·6	8·9	1 726	3 005	**58**, 60, 61, 62, 64
Nb	Niobium (or Columbium	41	92·91	5+	6·9	8·57	2 740	5 200	**93**
N	Nitrogen	7	14·01	3+ 5+	14·5	0·001 165	63·3	77·3	**14**, 15
No	Nobelium	102	254	—	—	—	—	—	—
Os	Osmium	76	190·2	4+	8·7	22·48	3 300	4 900	184, 186, 187, 188, 189, **190**, **192**
O	Oxygen	8	16·00	2−	13·6	0·001 33	54·7	90·2	**16**, 17, 18
Pd	Palladium	46	106·4	2+ 4+	8·3	12·0	1 825	3 200	102, 104, **105**, **106**, **108**, 110
P	Phosphorus	15	30·97	3+ 5+	10·5	1·8	317·2	552	**31**
Pt	Platinum	78	195·09	2+ 4+	9·0	21·45	2 040	4 100	190, 192, **194**, **195**, **196**, 198
Pu	Plutonium	94	244	—	—	—	914	3 505	— —
Po	Polonium	84	209	2+ 6+	8·4	9·4	530	1 235	— —
K	Potassium	19	39·10	1+	4·3	0·86	337	1 047	**39**, 41
Pr	Praseodymium	59	140·91	3+	5·4	6·8	1 210	3 400	**141**
Pm	Promethium	61	147	3+	5·6	—	1 310	3 000	—
Pa	Protoactinium	91	231	3+ 4+	—	15·4	1 500	4 300	—

8. Properties of the Elements (Contd.)

Symbol	Element	Atomic Number Z	Relative atomic Mass $M/\mathrm{g\ mol^{-1}}$	Principal oxidation numbers	Ionization energies $E/_e\mathrm{V}$	Density $\rho/\mathrm{kg\ m^{-3}}$ $\times 10^3$	Melting point T_m/K	Boiling point T_b/K	Stable isotopes*
Tb	Terbium	65	158·92	3+	5·9	8·3	1 630	3 100	**159**
Tl	Thallium	81	204·37	1+	6·1	11·86	580	1 730	**203**, **205**,
Th	Thorium	90	232·04	4+	7·0	11·5	2 000	4 500	—
Tm	Thulium	69	168·93	3+	6·2	9·3	1 820	2 000	**169**
Sn	Tin	50	118·69	2+ 4+	7·3	7·3	505	2 540	112, 114, 116, 117, **118**, 119, **120**, 122 124
Ti	Titanium	22	47·9	4+	6·8	4·54	1 950	3 530	46, 47, **48**, 49, 50
W	Tungsten	74	183·85	6+	8·0	19·32	3 650	6 200	180, **182**, 133, **184**, **186**
U	Uranium	92	238·03	4+ 6+	6·1	19·05	1 405	4 090	—
V	Vanadium	23	50·94	3+ 5+	6·7	6·1	2 160	3 300	50, **51**
Xe	Xenon	54	131·30	0	12·1	0 005 50	161·2	166	124, 126, 128, **129**, 130, **131**, **132**, 134, 136
Yb	Ytterbium	70	173·04	3+	6·3	7·0	1 100	1 700	168, 170, 171, **172**, 173, **174**, 176
Y	Yttrium	39	88·91	3+	6·4	4·6	1 770	3 200	**89**
Zn	Zinc	30	65·37	2+	9·4	7·14	693	1 180	**64**, **66**, 67, 68, 70
Zr	Zinconium	40	91·22	4+	6·8	6·50	2 130	3 850	**90**, 91, 92, 94, 96

* Isotopes in bold print form more than 20%

9. Mass Density of Substances

A. (i) Solids (alloys)

Substance	Density ρ/kg m^{-3} $\times 10^3$	Substance	Density ρ/kg m^{-3} $\times 10^3$
Brass (90 Cu, 10 Zn)	8·8	Magnalium (90 Al, 10 Mg)	2·5
Bronze (89 Cu, 9 Zn, 2 Pb)	8·83	Manganin (82 Cu, 15 Mn, 3 Ni)	8·5
Chromel (80 Ni, 20 Cr)	8·4	Monel (60 Ni, 33 Cu, 6·5 Fe)	8·9
Constantan or Eureka (60 Cu, 40 Ni)	8·4	Phosphor bronze (95·5 cu, 4·2 Sn, 0·2 P)	8·91
Duraluminium	2·79	Nichrome (60 Ni, 24 Fe, 16 Cr, 0·1 C)	8·17
Ferro aluminium (80 Fe, 20 Al)	6·3	Platinum iridium (90 Pt, 10 Ir)	21·61
Ferro-chromium (50 Fe, 50 Cr)	6·9	Stainless steel (85–86 Fe, 14 Cr, 0·35 C)	7·75
German silver (60 Cu, 25 Zn, 15 Ni)	8·7	White metal (75 Pb, 19 Sb, 5 Sn, 1 Cu)	9·5
Invar (64 Fe, 36 Ni)	8·0	Wood's metal (50 Bi, 25 Pb, 12·5 Sn, 12·5 Cd)	9·7
Iron, cast grey (95 Fe, 3 C, 2 Si)	7·0		
Iron, wrought (98·5 Fe)	7·7		

For densities of elements see pages 27·32.

9. Mass Density of Substances (Contd.)

A. (ii) Non-metallic solids

Substance	Density $\rho/\text{kg m}^{-3}$ $\times 10^3$	Substance	Density $\rho/\text{kg m}^{-3}$ $\times 10^3$
Agate	2·6	Ivory	1·9
Bamboo	0·4	Marble	2·7
Brick (building)	2·3	Mica	2·8
Bone	1·85	Porcelain	2·3
Carbon (graphite)	2·3	Sand	1·6
Carbon (diamond)	3·3	Wax (paraffin)	0·9
Concrete	2·4	Wax (sealing)	1·8
Cork	0·24	Wood (deal)	0·6
Cotton	1·5	Wood (rose)	0·9
Ebonite	1·2	Wood (teak)	0·8
Glass (crown)	2·6	Asbestos	2·4
Glass (flint)	4·2	Emery	4
Ice	0·92	Granite	2·5 – 3
India rubber	0·92	Quartz	2·65

A. (iii) Plastics

Substance	Density ρ/kgm^{-3} $\times 10^3$	Substance	Density $\rho/\text{kg m}^{-3}$ $\times 10^3$
Bakelite	1·3	Perspex	1·19
Cellon	1·3	Polystyrene	1·06
Celluloid (cellulose nitrate)	1·35 – 1·6	Polythene (polyethylene)	0·92
Cellulose ascetate	1·35	Polyvinyl chloride	1·37
Plexiglass	1·18	Shellac	1·11
Nylon	1·15	Tefflon	2·2
		Textolite	1·35

9. Mass Density of Substances (Contd.)

A. (iv) Compounds

Substance	Density ρ/kg m^{-3}	Substance	Density ρ/kg m^{-3}
	$\times 10^3$		$\times 10^3$
Ammonium chloride	1·54	Naphthalene	1·14
Camphor	0·99	Salt	2·2
Copper sulphate	2·28	Silicon carbide	3·17
Glucose	1·56	Silver nitrate	4·35
Hypo	1·73	Titanium oxide	4·50
Magnesium oxide	3·58	Urea	1·34

B. Liquids (at 293 K)

Substance	Density ρ/kg m^{-3}	Substance	Density ρ/kg m^{-3}
	$\times 10^3$		$\times 10$
Acetic acid	1·05	Kerosene	0·83
Acetone	0·78	Linseed oil	0·92
Aniline	1·02	Lubricating oil	0·91
Benzene	0·88	Methyl alcohol	0·79
Bromine	3·1	Methylated spirit	0·83
Carbon disulphide	1·29	Milk	1·03
Carbon tetrachloride	1·63	Nitrobenzene	1·18
Castor oil	0·97	Olive oil	0·92
Chloroform	1·49	Paraffin oil	0·8
Cocoanut oil	0·91	Petrol	0·70
Crude oil	0·81	Phenol	1·07
Ether, diethyl	0·714	Toulene	0·867
Ethyl alcohol	0·79	Turpentine	0·87
Formic acid	1·22	Water	1·0
Glycerol	1·26	Water-Sea	1·025

9. Mass Density of Substances (Contd.)

C. Gases at stp*

Substance	Density ρ/kg m^{-3}	Substance	Density ρ/kg m^{-3}
Acetylene	1·173	Hydrogen sulphide	1·538
Air	1·293	Methane	0·717
Ammonia	0·771	Nitric oxide	1·340
Carbondioxide	1·977	Nitrous oxide	1·978
Carbonmonoxide	1·250	Steam (at 100°C)	0·581
Cyanogen	2·337	Sulphur dioxide	2·927
Ethylene	1·260	Water vapour (at 0°C)	0·80
Hydrogen chloride	1·640		

* stp— Standard Temperature and Pressure

D. Density (kg m^{-3}) of water and mercury with temperature) at 1 atmosphere

Temperature t/°C	Mercury	Water	Temperature t/°C	Mercury	Water
1	13 595·08	999·87	60	13 448·25	983·2
2	13 590·15	999·97	70	13 423·98	977·8
4	13 585·22	1000	80	13 399·77	971·8
10	13 570·45	999·73	90	13 375·60	965·3
20	13 545·88	998·23	100	13 351·48	958·4
30	13 521·39	995·67	150	13 232·50	917
40	13 496·95	992·2	200	13 112·0	863
50	13 472·57	988·1			

Water has maximum density at 3·98°C (277·13 K)

9. Mass Density of Subtances (Contd.)

E. Density of dry air (kg $\mathrm{m^{-3}}$) at different temperatures and pressures

	mm of Hg	710	720	730	740	750	760	770	780
	$\mathrm{Nm^{-2}}$	94 600	95 900	97 300	98 600	100 000	101 325	102 600	104 000
Temperature t/°C	0	1·208	1·225	1·242	1·259	1·276	1·293	1·310	1·327
	5	1·186	1·203	1·220	1·236	1·253	1·270	1·286	1·303
	10	1·165	1·182	1·198	1·214	1·231	1·248	1·263	1·280
	15	1·145	1·161	1·177	1·193	1·209	1·226	1·241	1·258
	20	1·125	1·141	1·157	1·173	1·189	1·204	1·220	1·236
	22	1·117	1·133	1·149	1·165	1·180	1·195	1·212	1·228
	24	1·110	1·126	1·141	1·157	1·172	1·188	1·204	1·219
	26	1·103	1·118	1·134	1·149	1·165	1·180	1·196	1·211
	28	1·095	1·111	1·126	1·141	1·157	1·172	1·188	1·203
	30	1·088	1·103	1·119	1·134	1·149	1·165	1·180	1·195

10. Elastic Moduli (E, G, K) Solids

Substance	Young's Modulus E	Shear Modulus G	Bulk Modulus K	Poisson ratio μ	Tensile strength σ_T
	$G\ Nm^{-2}$	$G\ Nm^{-2}$	$G\ Nm^{-2}$		$M\ Nm^{-2}$
Aluminium	71	25·5	75	0·34	80
Antimony	78	20	—	—	—
Bismuth	32	12	32	0·33	—
Brass (70 Cu-30Zn)	100	35	100	0·35	550
Bronze (90Cu-10 Sn)	95	37	93	0·36	260
Constantan	170	61	155	0·33	—
Copper	117	45	135	0·35	150
Glass (crown)	71	30	50	0·235	—
Glass (flint)	80	22·5	37	0·24	—
German silver (60 Cu-25 Zn-15 Ni)	113	45	150	0·37	450
Gold	71	34	185	0·44	120
India rubber	0·5	—	—	0·48	—
Iron (cast)	110	50	100	0·27	100
Iron (wrought)	197	77	167	0·28	370
Lead	18	76	43	0·44	15
Magnesium	44	17	46	0·29	190
Manganin	120	47	120	0·33	—
Nickel	207	76	177	0·36	300
Perspex	6·2	2·3	6·0	0·33	—
Platinum	150	63	260	0·38	350
Phosphor bronze	110	43		0·38	800
Quartz fibre	73	31·2	36·9	0·17	1 000
Silk fibre	6·5	—	—	—	260
Silver	70	28	100	0·37	150
Steel (mild)	210	83	175	0·29	460
Tin	40	20	52	0·36	30
Tungsten	410	160	310	0·28	—
Zinc	110	43	72	0·25	130

Note: (1) Elastic constants are generally liable to vary slightly due to difference in manufacturing processes.

(2) For a homogeneous isotropic solid the following relations between these constants exist.

(a) $G = \frac{E}{2(1+\mu)}$ (b) $K = \frac{E}{3(1-2\mu)}$ (c) $K = \frac{1}{3}\ \frac{E\,G}{(3G-E)}$

11. Surface Tension and Compressibility of Liquids (293 K)

Substance	Surface tension $\sigma/\mathrm{Nm^{-1}}$	Compressibility $k/\mathrm{N^{-1}\,m^2}$
	$\times 10^{-3}$	$\times 10^{-9}$
	Against air	
Acetic acid	27·6	0·4
Acetone	23·7	1·25
Alcohol (ethyl)	22·3	0·76
Alcohol (methyl)	22·6	1·03
Aniline	42·9	0·45
Benzene	28·9	0·91
Bromine	41·5	0·63
Carbon disulphide	32·3	0·86
Carbon tetrachloride	26·8	0·90
Castor oil	36·4	0·47
Chloroform	27·1	0·93
Cocoanut oil	33·0	—
Ether (diethyl)	17·0	1·45
Glycerol	63·0	0·25
Kerosene	30·0	0·75
Mercury	472·0	0·038
Nitrobenzene	43·9	0·456
Olive oil	32·0	0·63
Paraffin oil	26·0	0·62
Phenol	40·9	—
Toulene	28·4	0·92
Turpentine	27·0	0·78
Water	72·7	0·49

12. Surface Tension of Water (against air) with Temperature

Temp. $t/°C$	Surface tension σ/Nm^{-3} $\times 10^{-3}$	Temp. $t/°C$	Surface tension σ/Nm^{-3} $\times 10^{-3}$
0	75·7	40	69·6
10	74·2	50	67·2
15	73·5	60	66·2
20	72·8	70	64·4
25	72	80	62·6
30	71·2	100	58·8

13. Viscosity of Liquids

Substance	Viscosity η/Nsm^{-2}					
	0°	10°	20°	30°	40°	50°
	$\times 10^{-3}$	$\times 10^{-3}$	$\times 10^{-3}$	$\times 10^{-3}$	$\times 10^{-3}$	$\times 10^{-3}$
Acetic acid	—	—	1·22	1·04	0·90	0·79
Acetone	0·400	0·36	0·32	0·30	0·27	0·25
Alcohol (ethyl)	1·78	1·46	1·20	1·00	0·83	0·70
Alcohol (methyl)	0·82	0·68	0·59	—	0·45	0·40
Aniline	10·2	6·53	4·39	3·18	2·4	1·91
Benzene	0·91	0·76	0·65	0·56	0·49	04·4
Bromine	0·241	—	0·99	—	—	—
Carbon disulphide	0·44	0·4	0·38	0·35	0·33	—
Carbon tetrachoride	1·35	1·14	0·97	0·85	0·74	0·66
Castor oil	6·406	2·420	986	451	231	125
Chloroform	0·70	0·63	0·57	0·52	0·47	0·43
Cocoanut oil	—	—	15·4	—	—	—
Ether (diethyl)	0·29	0·27	0·24	0·22	0·2	0·18
Glycerol	10·590	3·440	1·340	629	289	141
Kerosene	—	—	2·00	—	—	—
Mercury	1·68	1·66	1·55	1·50	1·45	1·41
Nitrobenzene	—	—	2·03	—	—	—
Olive oil	—	138	84·0	52	36	24·5
Paraffin oil	—	—	1 000·0	—	—	—
Phenol	—	—	12·74	—	—	—
Toulene	0·77	0·67	0·59	0·52	0·46	0·42
Turpentine	—	—	1·49	—	—	—
Water	1·79	1·30	1·00	0·80	0·65	50·5

14. Viscosity of Gases*

	Viscosity η/Nsm^{-2}		
Temperature	0°C	20°C	50°C
Substance	$\times 10^{-6}$	$\times 10^{-6}$	$\times 10^{-6}$
Acetylene	9·35	—	—
Air	17·1	18·1	19·5
Ammonia	9·18	—	—
Argon	21·2	22·2	24·2
Carbon dioxide	13·8	14·6	16·3
Carbon monoxide	16·6	17·7	18·9
Chlorine	12·9	13·2	14·5
Cyanogen	9·28	—	—
Ethylene	9·7	10·3	11·2
Helium	18·6	19·4	20·8
Hydrogen	8·35	8·8	9·3
Hydrogen chloride	13·8	—	—
Hydrogen sulphide	11·7	—	—
Methane	10·3	10·9	11·9
Nitric oxide	17·8	—	—
Nitrous oxide	13·5	14·6	16·0
Nitrogen	16·6	17·4	18·8
Oxygen	19·2	20·0	21·8
Sulphur dioxide	11·7	12·6	14·0
Water vapour (273 K)	8·7	—	—

*at one atmosphere pressure

15. Solubilities of Gases (in one litre of water at 303 K)

Gas	Volume at stp V/m^3 $\times 10^{-6}$	Gas	Volume at stp V/m^3 $\times 10^{-6}$
Acetylene	840	Hydrogen	17
Air	16·1	Hydrogen chloride	412 000
Ammonia	530 000	Hydrogen sulphide	1 970
Argon	28·0	Methane	27·6
Carbondioxide	650	Neon	17
Carbon monoxide.	20	Nitrogen	13·3
Chlorine	1 770	Nitric oxide	39
Ethylene	98	Oxygen	26
Helium	8·4	Sulphur dioxide	27·200

16. Thermal Properties

A. Solids

Specific heat capacity, specific latent heat of fusion, thermal conductivity, melting point, and linear expansivity

Substance	Specific heat capacity $\frac{c_p}{\mathrm{J\,kg^{-1}\,K^{-1}}}$	Specific latent heat of fusion $\frac{l}{\mathrm{J\,kg^{-1}}}$	Thermal conductivity $\frac{\lambda}{\mathrm{W m^{-1}\,K^{-1}}}$	Melting point T_m/K	Linear expansivity $\alpha/\mathrm{K^{-1}}$
		$\times 10^3$			$\times 10^{-4}$
Aluminium	904	389·2	205	932	0·23
Antimony	205	160·3	17·6	904	0·11
Bismuth	125·5	52·31	8·0	544	0·13
Brick	3·348	—	0·6	—	0·09
Brass	372·5	—	109·0	1 300	0·18
Bronze	360·0	—	180	1 300	0·17
Cadmium	209·2	54·41	93·0	594	0·30
Cardboard	—	—	0·21	—	—
Carbon (graphite)	711·4	—	5	3 800	0·08
Chromium	418·5	281	—	2 163	0·08
Cobalt	420·0	244·4	69	1 765	0·12
Concrete	3 348·0	—	0·13	—	0·12
Constantan	418·5	—	22·6	1 360	0·17
Copper	385·0	211·7	385	1 356	0·17
Cork	2 050·0	—	0·05	—	—
Ebonite	1 674·0	—	0·17	—	0·84
German silver	397·6	—	29·3	1 300	0·18
Glass (crown)	669·6	—	1·05	1 400	0·09
Glass (flint)	502·2	—	0·84	1 500	0·08
Gold	132·2	67·38	293	1 340	0·14
Ice	2 101·0	333·6	2·09	273·2	0·51
India rubber *	1 600·0	—	0·19	—	0·7
Invar	502·2	—	—	1 800	0·009

* Liable to vary widely.

16. Thermal Properties (Contd.)

A. Solids (Contd.)

Substance	Specific heat capacity c_p/J kg^{-1} K^{-1}	Specific latent heat of fusion l/J kg^{-1}	Thermal conductivity λ/Wm^{-1} K^{-1}	Melting point T_m/K	Linear expansivity α/K^{-1}
		$\times 10^3$			$\times 10^{-4}$
Iron (cast)	497·9	Grey 96·3 White 138·1	75	Grey 1 500 White 1 420	Grey 0·11 White 0·11
Iron (wrought)	481·2	140	60	1 810	0·12
Lead	125·6	26·4	35	600·5	0·29
Magnesium	246·0	380	150	924·2	0·26
Manganin	401·8	410	21·8	—	0·18
Marble	878·8	—	2·9	—	0·1
Naphthalene	1 310·0	148·9	—	353·2	1·07
Nickel	460·4	308·9	58·6	1 726	0·13
Paraffin wax	2 887·0	146·9	0·25	327·2	~1·10
Perspex	1 500·0	—	—	—	0·85
Phosphor bronze	—	—	—	1 320	0·17
Platinoid	—	—	25·1	—	—
Platinum	135·6	113·4	69·5	2 042	0·09
Quartz	786·8	565 – 1 090	9·2	2 025	0·17 (fibre)
Silica (fused)	—	—	1	1 975	—
Silver	234·4	101·7	419	1 230	0·192
Sodium	1 240·0	115·1	133	371	0·71
Sulphur	732·3	38·9	0·26	386	0·61
Tungsten	125·5	—	201	3 653	0·01
Tin	226·0	60·3	65	505	0·23
Wood	—	—	0·15	—	—
Zinc	385·0	100·9	111	693	0·31

16. Thermal Properties (Contd.)

B. Liquids

Melting point, boiling point, specific heat capacity, specific latent heat of vaporization thermal conductivity, cubic expansivity and critical temperature.

Substance	Melting point T_m/K	Boiling point T_b/K	Specific heat capacity c_p/J kg^{-1}K^{-1}	Specific latent heat of vaporization l/J kg^{-1}	Thermal conductivity λ/W m^{-1}K^{-1}	Cubic expansivity γ/K^{-1}	Critical temperature T_c/K
			$\times 10^3$	$\times 10^3$		$\times 10^{-3}$	
Acetic acid	290	391	1·96	390	0·180	1·07	594·4
Acetone	178	330	2·21	5 0	0·161	1·43	509
Alcohol (ethyl)	155·9	351·3	2·5	850	0·177	1·08	516·2
Alcohol (methyl)	179	337·9	2·5	1 120	0·201	1·19	512·6
Aniline	266·2	457·4	2·13	460	0·180	0·85	698·8
Benzene	278·6	353·4	1·70	400	0·140	1·22	562
Bromine	265·9	331·2	0·46	183	—	1·13	584
Carbon disulphide	161·6	319·2	1·00	360	0·144	1·19	552
Carbon tetrachloride	250·2	349·9	0·84	190	0·103	1·22	556
Castor oil	—	538·2	2·13	—	0·18	0·65	—
Chloroform	209·7	334·4	0·96	250	0·121	1·27	536·4
Cocoanut oil	298·2	559·2	2·05	—	—	0·74	—
Ether (diethyl)	157	307·5	2·3	350	0·127	1·63	467
Glycerol	293	563·2	2·4	830	0·270	0·47	—
Kerosene	—	513·2	2·09	301	0·159	—	—
Mercury	234·3	629·8	0·14	290	7·96	0·182	—
Nitrobenzene	278·9	484·2	1·4	330	0·16	0·86	—
Olive oil	—	573·2	1·97	—	0·17	0·70	—
Paraffin oil	—	—	2·13	—	0·15	90·0	—
Phenol	314	455	2·35	530	—	0·79	694·2
Toulene	1‾8·1	383·7	1·67	350	0·134	1·07	591·8
Turpentine	263·2	429·2	1·76	290	0·136	0·96	—
Water	273·2	372·2	4·19	2 260	0·591	0·21	647·3

16. Thermal Properties (Contd.)

C. Gases (stp)

Specific latent heat of vaporization, specific heat capacity, ratio of specific heats, thermal conductivity.

Substance	Specific latent heat of vaporization l/J kg^{-1}	Specific heat capacity c_p/J kg^{-1} K^{-1}	Ratio of specific heats $\gamma = (c_p/c_v)$	Thermal conductivity λ/W m^{-1} K^{-1}
	$\times 10^3$	$\times 10^3$		$\times 10^{-2}$
Acetylene	—	1·591	1·26	1·84
Air	213·3	0·992	1·402	2·41
Ammonia	1 369	2·189	1·31	2·18
Argon	157·3	0·523	1·667	1·62
Carbon dioxide	364·1	0·833	1·304	1·45
Carbon monoxide	210·9	1·05	1·297	2·32
Chlorine	280·4	0·477	1·36	0·72
Cyanogen	432·0	1·716	1·26	—
Ethylene	484·0	1·50	1·261	1·64
Helium	25·1	5·24	1·63	14·15
Hydrogen	452	14·31	1·408	16·84
Hydrogen chloride	413	0·795	1·40	—
Hydrogen sulphide	552	1·02	1·32	1·2
Methane	51b	2·218	1·313	3·02
Nitric oxide	462	0·971	1·394	2·38
Nitrous oxide	376	0·892	1·324	1·51
Nitrogen	209·3	1·038	1·401	2·43
Oxygen	242·8	0·913	1·40	2·44
Sulphur dioxide	402·6	0·645	1·26	0·77
Water vapour (273 k)	2 261	2·017	1·334	1·58

17. Specific heat Capacity of Water with Temperature at 1 atmosphere

Temp. $t/^\circ\mathrm{C}$	Specific heat capacity $c_p/\mathrm{J\ kg^{-1}\ K^{-1}}$ $\times 10^3$	Temperature $t/^\circ\mathrm{C}$	Specific heat capacity $c_p/\mathrm{J\ kg^{-1}\ K^{-1}}$ $\times 10^3$
0	4·217 4	55	4·182 1
2	4·210 4	60	4·184 1
5	4·201 9	65	4·186 5
10	4·191 9	70	4·189 3
15	4·185 5	75	4·192 5
20	4·181 6	80	4·196 1
25	4·179 3	85	4·200 2
30	4·178 2	90	4 204 8
35	4·177 9	95	4·210 0
40	4·178 3	100	4·215 7
45	4·179 2		
50	4·180 4		

18 (a) Saturated Vapour Pressure of Water $p_{\mathrm{sat}}\ \mathrm{K\,N_m}^{-2}$

Temp. $t/^\circ\mathrm{C}$	0	2	4	6	8
0	0·611	0·705	0·812	0·934	1·071
10	1·226	1·400	1·596	1·815	2·061
20	2·335	2·640	2·980	3·357	3·775
30	4·238	4·750	5·315	5·935	6·620
40	7·371	8·194	9·096	10·081	11·158
50	12·33	13·61	15·00	16·50	18·14
60	19·92	21·84	23·90	26·14	28·56
70	31·16	33·96	36·96	40·18	43·65
80	47·35	51·33	55·57	60·10	64·95
90	70·11	75·60	81·46	87·68	94·30
100	101·32	108·77	116·67	125·04	133·89
110	143·2	153·1	163·6	174·6	186·3

18 (b) Vapour Pressure of Mercury

Temp $t/^\circ\mathrm{C}$	0	20	40	60	80	100	120	140	160	180	200
Vapour Pressure $p_{\mathrm{sat}}/\mathrm{P_a}$	$2{\cdot}4\times10^{-2}$	0·16	0·81	3·3	11·9	36·4	99·5	247	559	1170	2304

19. Relative Humidities from Wet and Dry Bulb Thermometers

Dry bulb Temperature °C	Depression of the wet bulb/°C										
	0·5	1	1·5	2	2·5	3	3·5	4	4·5	5	5·5
0	91	81	73	64	55	46	38	29	21	13	5
2	92	84	76	68	61	52	45	37	29	22	14
4	93	85	78	71	64	57	49	43	36	29	22
6	93	86	80	73	66	60	54	48	41	35	29
8	94	87	81	75	69	63	57	51	46	40	35
10	94	88	82	77	71	66	60	55	50	44	39
12	95	89	83	78	73	68	63	58	53	48	43
14	95	90	85	79	75	70	65	60	56	51	47
16	95	90	85	81	76	71	67	63	58	54	50
18	95	91	86	82	77	73	69	65	61	57	53
20	96	91	87	83	78	74	70	66	63	59	55
22	96	92	87	83	80	76	72	68	64	61	57
24	96	92	88	84	80	77	73	69	56	62	56
26	96	92	88	85	81	78	74	71	67	64	61
28	96	93	89	85	82	78	75	72	69	65	62
30	96	93	89	86	83	79	76	73	70	67	64
32	96	93	90	86	83	80	77	74	71	68	65
34	97	93	90	87	84	81	78	75	72	69	66
36	97	94	90	87	84	81	78	75	73	70	67
38	97	94	91	88	84	82	79	76	74	71	68
40	97	94	91	88	85	82	80	77	74	72	69

19. Relative Humidities from Wet and Dry bulb Thermometers (Contd.)

Dry bulb Temperature/°C	Depression of the wet bulb °C								
	6	6·5	7	7·5	8	8·5	9	9·5	10
0	—	—	—	—	—	—	—	—	—
2	7	—	—	—	—	—	—	—	—
4	16	9	—	—	—	—	—	—	—
6	24	17	11	5	—	—	—	—	—
8	29	24	19	14	8	—	—	—	—
10	34	29	24	20	15	10	6	—	—
12	39	34	29	25	21	16	12	8	—
14	42	38	34	30	26	22	18	14	10
16	46	42	38	34	30	26	23	19	15
18	49	45	41	38	34	30	27	23	20
20	51	48	44	41	37	34	31	28	24
22	54	50	47	44	40	37	34	31	28
24	56	53	49	46	43	40	37	34	31
26	58	54	51	49	46	43	40	37	34
28	59	56	53	51	48	45	42	40	37
30	61	58	55	52	50	47	44	42	39
32	62	60	57	54	51	49	46	44	41
34	63	61	58	56	53	51	48	46	43
36	64	62	59	57	54	52	50	48	45
38	66	63	61	58	56	54	51	49	47
40	67	64	62	59	57	54	53	51	48

The relative humidity is defined as the ratio, expressed as a percentage, of the actual vapour pressure to the saturation vapour pressure at the temperature of the dry bulb.

20. Basic Fixed Points of Temperature

All fixed points relate to atmospheric pressure of 101 325 Nm^{-2} (760 mm of mercury)

Basic fixed points	T/K	t / °C
Boiling point of oxygen	90·18	−182·97
Ice point (freezing point of water)	273·15	0·00
Triple point of water	273·16	0·01
Boiling point of water (steam point)	373·15	100·00
Boiling point of sulphur	717·75	444·60
Melting point of silver	1 233·95	960·80
Melting point of gold	1 336·15	1 063·00

Some Secondary Fixed Temperatures

Carbon dioxide, sublimation	194·65	−78·5
Mercury, fusion	234·28	−38·87
Tin, fusion	505·05	231·9
Cadmium, fusion	594·05	320·9
Lead fusion,	600·45	327·3
Mercury, boiling	629·73	356·58
Aluminium, fusion	933·25	660·1
Nickel, fusion	1 726	1 453
Platinum, fusion	2 042	1 769
Tungsten, fusion	3 653	3 380

OPTICAL DATA

21. Electromagnetic Spectrum

Em Wave	Frequency ν/Hz	Wave-length λ/m
Radio waves	3×10^{12} to 3×10^{2}	10^{-4} to 10^{6}
Infra red	$3 \cdot 5 \times 10^{14}$ to 3×10^{11}	8×10^{-7} to 10^{-3}
Visible light spectrum	$7 \cdot 5 \times 10^{14}$ to $3 \cdot 5 \times 10^{14}$	4×10^{-7} (violet) to 8×10^{-7} (red)
Ultra violet	3×10^{16} to $7 \cdot 5 \times 10^{14}$	10^{-8} to 4×10^{-7}
X-rays	3×10^{19} to 3×10^{15}	10^{-11} to 10^{-7}
γ rays	3×10^{22} to 3×10^{18}	10^{-14} to 10^{-10}

Note:—The above values are based on the approximate value for the velocity of the Em wave

$$C = 3 \times 10^{8} \text{ m/s}$$

See table 23 for the radio wave spectrum alone.

22. Visible Spectrum

Frequency ν/Hz	Wave-lengh λ/nm	Colour sensation
$\times 10^{14}$		
$4 \cdot 0 - 4 \cdot 8$	$750 - 620$	Red
$4 \cdot 8 - 5 \cdot 1$	$620 - 590$	Orange
$5 \cdot 1 - 5 \cdot 3$	$590 - 580$	Yellow
$5 \cdot 3 - 6 \cdot 0$	$580 - 500$	Green
$6 \cdot 0 - 6 \cdot 5$	$500 - 460$	Blue
$6 \cdot 5 - 6 \cdot 7$	$460 - 450$	Indigo
$6 \cdot 7 - 7 \cdot 5$	$450 - 400$	Violet

$1 \text{ Å} = 10^{-10} \text{ m} = 10^{-1} \text{ nm}.$

1 Å is the symbol for angstrom unit of length used in spectroscopy.

1 nanometre $= 10^{-9}$ m

nm is the symbol for nanometre.

23. Radio Wave Spectrum

A table of frequency and wavelength
(Selected reference points)

Type of wave	Frequency (ν)	Wave length (λ)
1. Very low frequency (VLF)	10 kHz	30 km
	30 kHz	10 km
2. Low frequency (LF)	40 kHz	7·5 km
	100 ,,	3·0 km
	300 ,,	1·0 km
3. Medium frequency	400 kHz	750 m
	500 ,,	600 m
(i) Broadcast band	600 ,,	500 m
	1000 ,,	300 m
	1500 ,,	200 m
	2 MHz	150 m
(ii) Short wave band	3 MHz	100 m
	5 ,,	60 m
	10 ,,	30 m
	30 ,,	10 m
4. Very high frequency (VHF)	50 MHz	6 m
	300 ,,	1·0 m
5. Ultra high frequency (UHF)	400 MHz	750 mm
	1·0 GHz	300 mm
	3·0 ,,	100 mm
6. Super high frequency (SHF)	4·0 GHz	75 mm
	10·0 ,,	30 mm
	30·0 ,,	10 mm

24. Some standard sources with the wave-lengths of spectral lines emitted by them in nm

Helium	Sodium	Hydrogen	Mercury	Calcium ionized
667·815		656·282	579·065	
587·562	589·592	486·135	576·959	396·847
304·774	588·995	434·046	546·074	393·367
501·567		410·774	491·604	
492·193	Cadmium		435·835	
471·314	643·847	Iron	407·781	
447·148	508·582	526·959	404·656	
443·755	479·992	430·791		
438·793	467·816			

25. Wave-lengths of the Fraunhofer lines Sun's Spectrum

Line	due to	colour	Wave length λ/nm
K	Ca	v	393·368 4
H	Ca	v	396·849 4
h	H	v	410·175 0
g	Ca	b	422·674 2
G	Fe	b	430·791 4
G'	Hy	b	434·047 7
F	Hy	b	486·134 4
b_4	Mg	g	516·733 0
b_2	Mg	g	517·270 0
b_1	Mg	g	518·362 1
E_2	Fe	g	526·955 7
D_2	Na	oy	588·997 7
D_1	Na	oy	589·594 4
C	H	r	656·281 6
B	O	r	686·995 5
A	O	r	759·397

26. Wave-lengths for Spectroscope Calibration

Source	Wave-length λ/nm	Source	Wave-length λ/nm
Potassium flame	769·9	E Solar	527·0
Potassium flame	766·5	b_1 Solar or magnesium flame	518·4
Mercury arc	690·7	b_2 Solar or magnesium flame	517·3
B Solar	686·9	Mercury arc	496·0
Lithium flame	670·8	Mercury arc	491·6
C Solar	656·3	F, Solar or hydrogen tube	486·1
Mercury arc	623·4	Strontium flame	460·8
D_1 Solar (Na flame)	589·6	Mercury arc	435·8
D_2 Solar (Na flame)	589·0	G, Solar or hydrogen tube	434·0
Mercury arc	579·1	Mercury arc	404·7
Mercury arc	577·0	H, solar	396·9
Mercury arc	546·1	K, solar	393·4
Thallium flame	535·1		

27. Refractive Indices (n) against air for mean sodium D-line

$\lambda = 589{\cdot}3$ nm

Substance	Refractive index (n)	Substance	Refractive index (n)	Substance	Refractive index (n)
Canada balsam	1·530	Acetic acid	1·372	Acetylene	1·000 606
Diamond	2·4195	Aniline	1·586	Air	1·000 292
Felspar	1·52	Alcohol, ethyl	1·361	Ammonia	1·000 376
Fluorspar	1·434	Alcohol, methyl	1·328	Argon	1·000 281
Glass (crown)	1·48–1·61	Benzene	1·501	Carbon dioxide	1·000 451
Glass (flint)	1·53–1·96	Bromine	1·66	Carbon monoxide	1·000 338
Ice	1·31	Carbon disulphide	1·628	Chlorine	1·000 773
Perspex	1·495	Castor oil	1·472	Ethylene	1·000 696
Quartz	1·488	Cocoanut oil	1·450	Helium	1·000 036
Rocksalt	1·544	Ether, diethyl	1·354	Hydrogen	1·000 132
Ruby	1·76	Glycerol	1·473	Hydrogen chloride	1·000 447
Potassium Iodide	1·667	Mercury	1·73	Hydrogen sulphide	1·000 634
Polystrene	1·591	Linseed oil	1·474	Methane	1·000 444
Silver chloride	2·09	Nitro-benzene	1·553	Neon	1·000 067
Silver bromide	2·25	Olive oil	1·48	Nitric oxide	1·000 297
Sodium chloride (natural)	1·544	Paraffin oil	1·43	Nitrogen	1·000 297
Sodium fluoride	1·326	Toulene	1·497	Oxygen	1·000 272
Sylvine (KCl)	1·490	Turpentine	1·48	Sulphur dioxide	1·000 686
Zinc sulphide	2·370	Water	1·333	Water vapour	1·000 254

* Gases at stp

28. Index of Refraction. Biaxial Minerals - Sodium D line

Substance	n_α	n_β	n_γ
Aluminite $Al_2 O_3 SO_3 9H_2 O$	1·459	1·464	1·470
Gypsum $Ca SO_3 2H_2 O$	1·520	1·523	1·530
Topaz	1·619	1·620	1·650
Barite	1·633	1·642	1·653
Sulphur	1·950	2·043	2·240
Borax	1·447	1·470	1·472
Talc	1·539	1·589	1·589

29. Specific Rotation

Specific Rotation or rotatory power varies with the wave-length used, with temperature and in the case of solutions with the concentration. The values given below are for the sodium D, i.e., for a value $\lambda = 589 \cdot 3$ nm. + signifies right handed rotation and left. Specific rotation is given in degrees per millimetre for solids and in degrees per dm in the case of liquids and solutions.

Substance (solids)	Rotation deg/mm	Substance	Solvent	Temp. t/°C	Specific rotation deg/dm
Cinnabar (HgS)	+32·5	Amyl alcohol	—	—	−5·7
Lead hyposulphate	+ 5·5	Turpentine	—	20	−37
Potassium hyposulphate	+ 8·4	Nicotine	—	10 – 30	− 162
Quartz	+21·68	Surcose	water	20	+66·45
Sodium bromate	+ 2·8	(Cane sugar)			
Sodium chlorate	+ 3·13	Lactose	water	20	+52·4

ACOUSTIC DATA

30. Velocity of Sound

Substance at 293 K	Velocity ν/ms^{-1}	Substance	Temp. t/°C	Velocity ν/ms^{-1}	Substance at 273 K	Velocity ν/ms^{-1}
Aluminium	5 100	Acetone	20	1 190	Air	331·5
Brass (70 Cu, 30 Zn)	3 480	Alcohol (ethyl)	20	1 162	Ammonia	415·0
Brick	3 650	Alcohol (methyl)	20	1 121	Argon	307·8
Copper (rolled)	3 750	Aniline	20	1 656	Carbon monoxide	337·6
Cork	500	Benzene	20	1 321	Carbon dioxide	258·0
Ebonite	1 575	Carbon disulphide	20	1 133	Chlorine	204·5
Glass	5 000	Carbon tetrachloride	20	938	Ethylene	317·0
Iron	5 000	Castor oil		1 494	Helium	971·9
Marble	3 800	Chloroform	20	977	Hydrogen	1 286·0
Nickel	4 900	Glycerol	20	1 941	Methane	430·0
Platinum	2 800	Kerosene	20	1 335	Neon	435·0
Silver	2 680	Mercury	20	1 454	Nitric oxide	325·0
Slate	4 510	Olive oil	20	1 435	Nitrogen	336·8
Steel (1 % C)	5 180	Water (distilled)	20	1 483	Oxygen	314·8
Wood	3 000–5 000	Water (sea)	20	1 522	Sulphur dioxide	211
Zinc	3 700				Water vapour (373 K)	405

Notes :—The velocity of sound varies according to the crystaline structure and previous history of the specimen. The values given for solids are for longitudinal waves.

31. Table of Phons I

Loudness level

	Phons		Phon
Threshold of hearing	0	Heavy traffic	60—70
Gentle rustle of leaves	0—10	Very loud music broadcast	70—80
Speech in adjoining room	10—20	Electric horn at 4 m	80—90
Whisper	20—30	Motor cycle without silencer	90—100
Quiet speech	30—40	Aircraft engine at 4 m	120
Business premises	40—50	Threshold of pain	130
Loud conversation	50—60		

32. Table of Phons II

Threshold of audibility	...	0
Quiet whisper	...	20
Quiet suburban garden	...	30
Clock ticking briskly	...	40
Soft radio music	...	50
Moderate conversation	...	60
Loud radio speech	...	70
Loud radio music	...	80
Near pneumatic drill	...	100
Near unsilenced aeroplane engine	...	110
Tickling in the ear	...	130

33. Acceptable Noise Levels

	dB	Remarks
Hospitals	30—40	Limits of audibility 25-25 000 Hz approximately
Living rooms	35—40	Ordinary conversation—average power 10μ watts
Libraries	30—35	Shouting-average power 1000 μ watts
Bedrooms	20—25	
Public offices	45—55	
Workshops	65—70	

34. Diatonic Scale

Note	C		D		E		F		G		A		B		C
Frequency	256		288		320		341·3		384		426·7		480		512
Relative frequency	1		$\frac{9}{8}$		$\frac{5}{4}$		$\frac{4}{3}$		$\frac{3}{2}$		$\frac{5}{3}$		$\frac{15}{8}$		2
Interval		$\frac{9}{8}$		$\frac{10}{9}$		$\frac{16}{15}$		$\frac{9}{8}$		$\frac{10}{9}$		$\frac{9}{8}$		$\frac{16}{15}$	

35. Equally Tempered Scale

(The scale divides the octave into twelve equal intervals each being

$$\sqrt[12]{2} = 1{\cdot}0595$$

The twelve notes calculated for 256 as fundamental correct to the nearest integer are as follows:

256, 271, 287, 305, 322, 342, 361, 384, 399, 431, 456, 483 & 512

The frequencies indicated are the ones generally adopted in Physics. In music, the international standard of concert pitch is based on 440 Hz for 'A' which will make the middle 261·63 Hz.

36. Musical Intervals

Name	Interval ratio	log cents	Name	Interval ratio	log cents
Octave	2	1200	Major tone	9 : 8	204
Fifth	3 : 2	702	Minor tone	10 : 9	182
Fourth	4 : 3	498	Semi tone	16 : 15	112
Major third	5 : 4	386	Comma	81 : 80	22
Minor third	6 : 5	316			

$$\text{Interval } M/N = \left[\frac{1200 \log (M/N)}{\log 2}\right] \text{ log cents.}$$

37. Table of decibles expressed as Voltage and Power ratios

Decibels dB	Voltage ratio (V_1/V_0)	Power ratio (P_1/P_0)
0	1·0	1·0
0·1	1·012	1·022
0·2	1·023	1·047
0·3	1·035	1·072
0·4	1·047	1·097
0·5	1·059	1·122
0·6	1·072	1·148
0·7	1·084	1·175
0·8	1·097	1·202
0·9	1·109	1·230
1·0	1·122	1·259
1·2	1·148	1·318
1·4	1·175	1·380
1·6	1·202	1·445
1·8	1·230	1·514
2·0	1·259	1·585
2·2	1·288	1·660
2·4	1·318	1·738
2·6	1·349	1·820
2·8	1·380	1·906
3·0	1·413	1·995
3·5	1·496	2·239
4·0	1·585	2·512
4·5	1·679	2·818
5·0	1·778	3·162
5·5	1·884	3·548
6·0	1·995	3·981
7·0	2·239	5·012
8·0	2·512	6·310
9·0	2·818	7·943
10·0	3·162	10·000
11	3·549	12·59
12	3·981	15·85
13	4·467	19·95
14	5·012	25·12
15	5·623	31·62
16	6·310	39·81
17	7·079	50·12
18	7·943	63·10
19	8·913	79·43
20	10·000	100·00
25	17·78	316·00
30	31·62	1000·00
35	56·23	3162·00
40	100·00	10^4
45	177·8	31 620
50	316·2	10^5
60	10^3	10^6
80	10^4	10^8
100	10^5	10^{10}

ELECTRIC AND MAGNETIC DATA

38. Electrical Resistivity and Temperature Coefficient

Substance	Electrical resistivity 273 K ρ/Ω m	Temperature coefficient of resistance $\left(\frac{1}{\rho_0}\right)\left(\frac{d\rho}{dT}\right)/$ K^{-1} (over range 0° to 100°)
	$\times 10^{-9}$	$\times 10^{-3}$
Aluminium	24·5	4·5
Antimony	390·0	5·1
Bismuth	1070·0	4·6
Brass (293 K) (70 Cu 30 Zn)	~80	~1·5
Carbon (graphite)	3 500—63 000	—
Chromium	127	—
Cobalt	56	6·6
Constantan	490	±0·04
Copper	15·6	4·3
German silver (293 K)	330	0·4
Gold	20·4	4·0
Invar (293 K)	810	2·0
Iron (cast, grey)	100	—
Iron (wrought)	140	6
Lead	190	4·2
Magnesium	39	4·25
Manganin	415	±0·01
Mercury	941	1·0
Nichrome (293 K)	1 110	0·35
Nickel	61	6·8
Phosphor bronze (293K)	70	6·0
Platinoid	344	0·25
Platinum	98·1	3·92
Silver	15·1	4·1
Sodium	42	5·5
Steel (mild) 293 K	150	5·0
Tin (293 K)	115	4·6
Tungsten	49	4·8
Zinc	55	4·2
Bakelite	$7{\cdot}5 \times 10^{13}$	
Ebonite	$20{\cdot}0 \times 10^{13}$	
Fibre	2×10^{7}	
Glass	2×10^{11}	
Mica	2×10^{15}	
Paraffin	5×10^{14}	
Porcelain	3×10^{12}	
Rubber	1×10^{16}	
Shellac	1×10^{14}	
Soil (damp)	50	
Water	1×10^{4}	
Water (Sea)	21×10^{-2}	

For the insulating materials values given are approximate only.

39. Standard Wire Gauge—Resistance Values at 15°C

SWG No.	Dia d/mm	Area of cross section A/mm²	Copper (Ohms per 10^3 metres)	EUREKA OR CONSTANTAN (Ohms per 10^3 metres)	GERMAN SILVER (Ohms per 10^3 metres)	MANGANIN (Ohms per 10^3 metres)	PLATINOID (Ohms per 10^3 metres)	NICHROME (Ohms per 10^3 metres)
10	3·251	8·302	2·1	57	27	51	49	70
12	2·642	5·481	3·2	86	41	77	75	106
14	2·032	3·243	5·4	146	70	131	126	180
16	1·626	2·076	8·3	228	109	204	197	280
18	1·219	1·168	14·8	405	193	361	342	498
20	0·914 4	0·656 7	26·0	722	345	645	622	888
22	0·711 2	0·397 3	43·5	1 200	570	1 070	1 030	1 480
24	0·558 8	0·245 3	70·5	1 930	920	1 730	1 670	2 370
26	0·457 2	0·164 2	105	2 890	1 380	2 580	2 500	3 550
28	0·375 9	0·111 0	155	4 270	2 020	3 820	3 690	5 250
30	0·315 0	0·077 91	222	6 080	2 900	5 450	5 250	7 480
32	0·274 3	0·059 10	293	8 020	3 830	7 180	6 810	9 860
34	0·233 7	0·042 89	404	11 100	5 270	9 900	9 550	13 700
36	0·193 0	0·029 27	590	16 200	7 740	14 500	14 000	19 900
38	0·152 4	0·018 24	950	26 000	12 400	23 200	22 500	32 000
40	0·121 9	0·011 68	1 480	40 600	19 400	36 300	35 100	49 900

Composition of alloys by weight:

Eureka or Constantan:	60 Cu, 40 Ni
German Silver	60 Cu, 15 Ni, 25 Zn
Manganin	84 Cu, 4 Ni, 12 Mn
Platinoid	Same as German Silver, with about 1% tungsten (W)

40. EMF of Standard Cells

Weston (Cadmium) Cell

$$E_t = 1{\cdot}0186 - 0{\cdot}000\,040\,6\,(t-20) - 9{\cdot}5\times10^{-7}\,(t-20)^2$$

absolute volts

Clark cell

$$E_t = 1{\cdot}433\,3 - 0{\cdot}001\,19\,(t-15) - 7\times10^{-6}\,(t-15)^2$$

absolute volts

(t=temperature in degrees Celsius)

EMF of Cells (approximate)

Bichromate	2·0 volts	Lead-Acid cell (Accumulator	1·85—2·2 volts
Bunsen	1·9 ,,	Dry cell	1·5 volts
Daniel	1·08 ,,	Nickel-cadmium	1·3 ,,
Grove	1·8 ,,	Nickel-iron	1·4 ,,
Leclanche	1·46 ,,	Zinc-silver oxide	1·8 ,,

41. Temperature-EMF Data for Thermocouples

(EMF is in millivolts. Cold junctions at 0°C)

Hot junction Temperature t/°C	Copper-Constantan E/m V	Iron-Constantan E/m V	Platinum-10% Rhodium-Platinum E/m V	Hot junction Temperature t/°C	Iron-Constantan E/m V	Platinum-10% Rhodium-Platinum E/m V
0	0	0	0	450	24·61	3·73
10	0·39	0·5	0·055	500	27·39	4·22
20	0·78	1·02	0·112	550	30·22	4·72
30	1·19	1·54	0·172	600	33·11	5·23
40	1·60	2·06	0·233	650	36·08	5·74
50	2·02	2·58	0·297	700	39·15	6·27
60	2·45	3·11	0·363	750	42·32	6·80
70	2·89	3·65	0·430	800	45·53	7·34
80	3·33	4·19	0·499	850	48·73	7·89
90	3·78	4·73	0·570	900	—	8·45
100	4·24	5·27	0·642	1 000	—	9·59
120	5·18	6·36	0·791	1 100	—	10·76
140	6·14	7·45	0·945	1 200	—	11·95
160	7·13	8·56	1·104	1 300	—	13·16
180	8·14	9·67	1·268	1 400	—	14·37
200	9·18	10·78	1·435	1 500	—	15·58
250	11·86	13·56	1·866	1 600	—	16·77
300	14·67	16·33	2·314	1 700	—	17·92
350	17·58	19·09	2·777	1 750	—	18·48
400	20·59	21·85	3·249			

Constantan: 60 Cu, 40 Ni

42. Relative Permittivity (ϵ_r) (at 293 K)

Values refer to low frequencies and gases at stp

Substance	ϵ_r	Substance	ϵ_r	Substance	ϵ_r
Asbestos	5·8	Alcohol (ethyl)	25·7	Air	1·000 576
Bakelite	4·5	Alcohol (methyl)	33·0	Argon	1·000 556
Ebonite	2·8	Benzene	2·28	Ammonia	1·007 1
Fibre	4·5	Bromine	3·10	Carbon dioxide	1·000 988
Ice (268 K)	75	Carbon bisulphide	2·62	Helium	1·000 070
Marble	8	Castor oil	4·5	Hydrogen	1·000 272
Mica	7	Ethyl ether	4·34	Neon	1·000 13
Paraffin wax	2·2	Glycerine	43·0	Nitrogen	1·000 588
Perspex	3·5	Nitrobenzene	35·7	Oxygen	1·000 531
Polyethylene	2·3	Paraffin oil	2·2	Sulpurdioxide	1·000 82
Polystrene	2·55	Pentane	1·83	Water vapour (393 K)	1·000 60
Polyvinyl chloride	3·2	Toulene	2·39		
Rubber (natural)	2·4	Turpentine	2·23		
Shellac	3—3·7	Transformer oil	2·2		
Sulphur	3·4	Water	80·1		

Values of ϵ_r are pure numbers

Note : ϵ = absolute permittivity of a substance

$= \epsilon_o \times \epsilon_r$ where ϵ_o = absolute permittivity of vacuum

$= 8{\cdot}854 \times 10^{-12}$ F/m.

43. Magnetic Mass Susceptibility χ_{m} (at 293 K)

$\chi_{\mathrm{m}} = (\mu_{\mathrm{r}} - 1)/\rho$ where μ_{r} is the relative permeability and ρ the density of the material. + indicates a paramagnetic and — indicates a diamagnetic substance.

Substance	$\dfrac{\chi_{\mathrm{m}}}{\mathrm{kg^{-1}\,m^3}}$	Substance	$\dfrac{\chi_{\mathrm{m}}}{\mathrm{kg^{-1}\,m^3}}$
	$\times 10^{-8}$		10^{-8}
Aluminium	+ 0·82	Phosphorous	— 1·13
Araldite	— 0·63	Polyethlene	+ 0·2
Antimony	— 1·09	P.V.C.	— 0·75
Argon	— 0·60	Platinum	+ 1·22
Bismuth	— 1·70	Pottassium	+ 0·65
Carbon (graphite)	— 4·4	Silicon	— 0·16
Copper	— 0·107	Silver	— 0·25
Ebonite	+ 0·75	Sodium	+ 0·75
Germanium	— 0·15	Sodium chloride	— 0·63
Glass	— 1·3	Sulphur	— 0·62
Gold	— 0·19	Uranium	+ 2·19
Helium	— 0·59	Water	— 0·90
Hydrogen	— 2·49	Xenon	— 0·40
Krypton	— 0·4	NO	+ 59·3
Lead	— 0·15	CO_2	— 0·59
Mercury	— 0·21	Ferric hydroxide	+197
Neon	— 0·41	Ferrous sulphate	+ 52·2
Nitrogen	— 0·54	Manganese chloride	+134
Oxygen	+133·6	Manganese dioxide	+ 48·3
Perspex	— 0·5	Manganese sulphate	+111

44. Magnetic Elements of Some Stations

Station	Latitude	Longitude	Horizontal component of earth's magnetic field H/Am⁻¹	Declination D/°	Angle of Dip I/°
Allahabad	25° 27′ N	81° 44′ E	28·25	—	35
Bangalore	—	—	29·92	— 1·7	11
Bombay	18° 54′ N	72° 49′ E	29·20	— 0·3	22
Calcutta	22° 35′ N	88° 21′ E	31·2	— 0·82	29·9
Capetown	33° 56′ S	18° 28′ E	9·86	24·6	—65·1
Dehra Dun	30° 20′ N	78° 3′ E	26·34	2·0	43
Delhi	28° 40′ N	77° 14′ E	27·62	1·4	38
Edinburgh	55° 57′ N	3° 13′ W	13·2	— 9·4	70·1
Hyderabad			29·97	— 1·0	20
Leningrad	59° 55′ N	30° 25′ E	12·1	7·0	72·8
London (Teddington)	51° 25′ N	0° 20′ W	15·0	— 7·0	66·8
Madras	13° 5′ N	80° 18′ E	32·4	— 2·21	9·1
New York	40° 40′ N	73° 50′ W	14·6	—11·6	71
Paris	48° 52′ N	2° 20′ E	16·0	— 5·5	64·7
Sydney	33° 55′ S	151° 10′ E	20·2	11·9	—64·1
Tokyo	35° 40′ N	139° 45′ E	24·3	— 6·4	48·3
Tiruchirappalli	—	—	30·16	— 2·2	6
Vizagapatnam	—	—	30·24	— 1·0	20

*Declination is positive eastward

Angle of Dip is positive downwards

45. GENERAL Energy Equivalents

Energy associated with	Basic equation	Joule	eV	u	Hz	K
1 Joule (J)	—	1	$6{\cdot}242 \times 10^{18}$	$6{\cdot}702 \times 10^{9}$	$1{\cdot}509 \times 10^{33}$	$7{\cdot}244 \times 10^{22}$
1 electron Volt (eV)	$E = eV$	$1{\cdot}602 \times 10^{-19}$	1	$1{\cdot}074 \times 10^{-9}$	$2{\cdot}418 \times 10^{14}$	$1{\cdot}160 \times 10^{4}$
1 unified mass unit (u)	$E = mc^2$	$1{\cdot}492 \times 10^{-10}$	$9{\cdot}313 \times 10^{8}$	1	$2{\cdot}251 \times 10^{23}$	$1{\cdot}081 \times 10^{13}$
1 Hertz (Hz)	$E = h\nu$	$6{\cdot}626 \times 10^{-34}$	$4{\cdot}136 \times 10^{-15}$	$4{\cdot}441 \times 10^{-24}$	1	$4{\cdot}800 \times 10^{-11}$
1 Kelvin (K)	$E = KT$	$1{\cdot}381 \times 10^{-23}$	$8{\cdot}620 \times 10^{-5}$	$9{\cdot}255 \times 10^{-14}$	$2{\cdot}084 \times 10^{10}$	1

u = exactly 1/12th the mass of pure carbon 12

46. MOHS Hardness Scale

Substance	Hardness	Substance	Hardness
Talc	1	Topaz	9
Gypsum	2	Garnet	10
Calcite	3	Fused zirconia	11
Fluorite	4	Fused aluminia	12
Apatite	5	Silicon carbide	13
Felspar	6	Boron carbide	14
Vitreous silica	7	Diamond	15
Quartz	8		

Approximate Hardness of Some Materials

Substance	Hardness	Substance	Hardness
Agate	6—7	Garnet	6·5—7
Aluminium	2—3	Glass	4·5—6·5
Asbestos	5	Gold	2·5—3
Asphalt	1—2	Graphite	0·5—1
Boron	9·5	Lead	1·5
Brass	3—4	Marble	3 —4
Copper	2·5—3	Platinum	4·3
Carborundum	9—10	Silicon	7
Chromium	9	Silver	2·5—2·7
Emery	7—9	Steel (mild)	4·5

47. ELECTRONICS

Colour codes for resistors and fuses

Resistors

A colour code system consisting of three or four coloured bands or dots is used to indicate both the nominal value of the resistor and the permitted tolerance on that value. To read the codes correctly the resistor must be held in such a position that the coloured bands or dots appear at the left and the value is then read from left to right.

Colour band system

The first band indicates the first digit, the second band indicates the second digit and the third band indicates the number of zeros which follow the two previous digits. The fourth band indicates the tolerance, e.g., A fixed carbon resistor colour coded yellow, violet, orange and silver would read, four, seven, three zeros and 10 per cent, meaning 47 000 ohms resistance with a resistance tolerance of ± 10 %.

An earlier code consisted of a body colour, an end colour, and a dot or band in the centre. The body colour represented the first digit, the end or tip colour the second digit and the band or dot colour at the centre the number of zeros.

Colours used			
Black	0	Green	5
Brown	1	Blue	6
Red	2	Violet	7
Orange	3	Grey	8
Yellow	4	White	9

Tolerance	
No band	20%
Silver band	10%
Gold band	5%

FUSES

Code of coloured dots on the glass of the fuse giving the rating of the fuse

Black	60 mA
Grey	100 mA
Red	150 mA
Brown	250 mA
Yellow	500 mA
Green	750 mA
Dark blue	1·0 A
Light blue	1·5 A
Purple	2·0 A
White	3·0 A
Black and white	5·0 A

PART III

Mathematical Signs, Symbols and Formulae

1. Mathematical Constants

	Value	Logarithm to base 10
π	3·141 6	0·497 1
$\frac{4}{3}\pi$	4·188 8	0·622 1
π^2	9·869 6	0·994 3
π^3	31·006	1·491 4
$1/\pi$	0·318 3	$\bar{1}$·502 9
$1/\pi^2$	0·101 3	$\bar{1}$·005 7
$\sqrt{\pi}$	1·772 5	0·248 6
$\sqrt{2}$	1·414 2	0·150 5
$\sqrt{3}$	1·732 1	0·238 6
$\sqrt{10}$	3·162 3	0·500 0
e	2·718 3	0·434 3
1/e	0·367 9	$\bar{1}$ 565 7
$\sqrt{e}$	1·648 7	0·217 2
$\log_e 10$ = in 10	2·302 6	0·362 2
1 degree	0·017 45 radian	$\bar{2}$·241 7
1 radian	57·30	1·758 2

2. Greek Alphabet

Α	α	Alpha	Η	η	Eta	Ν	ν	Nu	Τ	τ	Tau
Β	β	Beta	Θ	θ	Theta	Ξ	ξ	Xi	Υ	υ	Upsilon
Γ	γ	Gamma	Ι	ι	Iota	Ο	ο	Omicron	Φ	φ	Phi
Δ	δ	Delta	Κ	κ	Kappa	Π	π	Pi	Χ	χ	Chi
Ε	ε	Epsilon	Λ	λ	Lambda	Ρ	ρ	Rho	Ψ	ψ	Psi
Ζ	ζ	Zeta	Μ	μ	Mu	Σ	σ	Sigma	Ω	ω	Omega

3. Mathematical Signs or Symbols & Abbreviations

No.	Sign or Symbol	Meaning	No.	Sign or Symbol	Meaning
1	$=$	equal to	13	$\geq$	greater than or equal to
2	$\neq$	not equal to			
3	$\equiv$	identically equal to	14	$\ll$	much less than
4	$\triangleq$	corresponds to	15	$\gg$	much greater than
5	$\approx$	approximately equal to	16	Σ	sum (of all terms of type specified)
			17	π	product of
6	$\rightarrow$	approaches	18	$(\ )$	brackets
7	$\simeq$	asymptotically equal to	19	$\sqrt[n]{\ }$	*n*th root
8	$\propto$	proportional to	20	$\lvert\ \rvert$	magnitude or numerical value of term enclosed (irrespective of sign or vectorial sign)
9	∞	infinity			
10	$<$	less than			
11	$>$	greater than			
12	$\leqq$	less than or equal to	21	$\angle\underline{n}$ or $n!$	$1 \times 2 \times 3 \ldots \times n$

4. Mathematical Symbols

No.	Name	Letter
1	Ordinary differential sign	d
2	Partial differential sign	∂
3	A small difference or increment, partial differential	δ
4	Increment, not necessarily small	Δ
5	Base of natural logarithm	e or e
6	Imaginary unit	i
	Complex vector operator	j
7	Cartesian co-ordinates	x, y, z
8	Cylindrical co-ordinates	ρ, ϕ, z
9	Spherical co-ordinates	r, θ, ϕ

5. Area of Surface, Volume, Centre of Gravity etc.

A. Regular Solids

Geometrical form	Area of curved surface	Volume	Position of centre of gravity
1. Sphere (radius r)	$4 \pi r^2$	$\frac{4}{3} \pi r^3$	Centre
2. Hemisphere (radius r)	$2 \pi r^2$	$\frac{2}{3} \pi r^3$	$\frac{3}{8}$ r from base along line of symmetry
3. Spherical segment (height h, radius of base a)	$2 \pi ah$	$\frac{1}{6} \pi h \times (h^2 + 3a^2)$	$\frac{h}{2} \left[\frac{2a^2 + h^2}{3a^2 + h^2} \right]$ from base along line of symmetry
4. Cylinder (length l, radius r)	$2 \pi rl$	$\pi r^2 l$	Centre of axis
5. Right cone radius of base r, height h)	$n r \sqrt{r^2 + h^2}$	$\frac{1}{3} \pi r^2 h$	$\frac{1}{4}$ h from base along line of symmetry
6. Ellipsoid (axes 2a, 2b, 2c)		$(\frac{4}{3}) \pi abc$	Centre
7. Anchor ring (mean radius R, radius of circular section r)	$4 \pi^2 rR$	$2 \pi^2 r^2 R$	Centre

5. Area of Surface, Volume, Centre of Gravity etc. (Contd.)

B. Plane figures

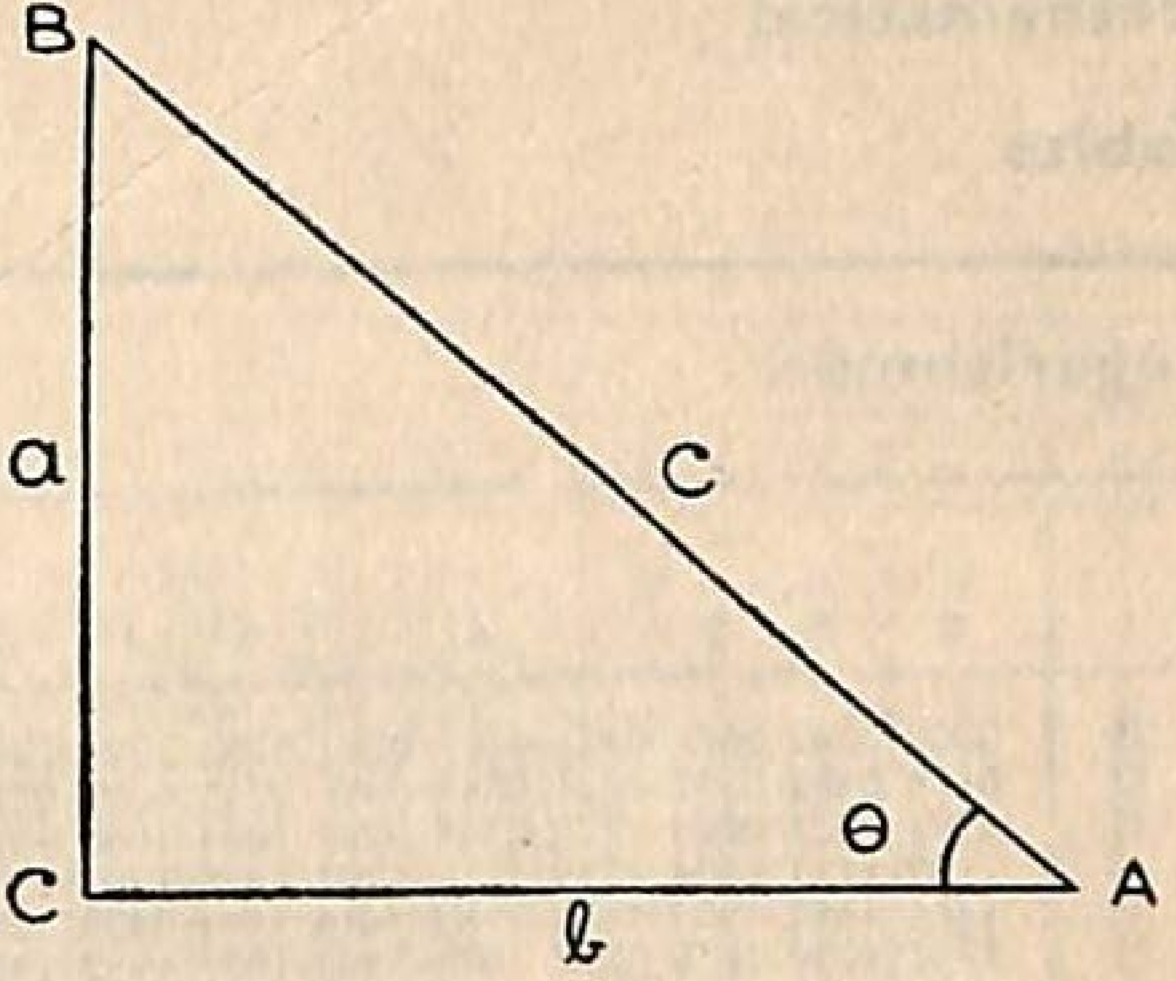
Geometrical form	Perimeter	Area of surface	Position of centre of gravity
1. Triangle (sides a, b, c)	$a+b+c=2s$	$\sqrt{s(s-a)(s-b)(s-c)}$	Point of intersection of medians
2. Circle (radius r)	$2\pi r$	πr^2	Centre
3. Semi-circle (radius r)	$r(\pi+2)$	$\pi r^2/2$	$4r/3\pi$ from centre along line of symmetry
4. Sector of circle radius r, length of arc l, length of chord c, subtended angle θ)	$\frac{2\pi r\theta}{360}+2r$	$\frac{\pi r^2\theta}{360}=\frac{lr}{2}$	$\frac{2}{3}\frac{rc}{l}$ from centre along line of symmetry
5. Ellipse (axes 2a, 2b)	$2\pi\sqrt{\frac{a^2+b^2}{2}}$ (approximately)	πab	Centre of figure
6. Regular pentagon (side a)	5a	$1{\cdot}721\ a^2$	Centre of figure
7. Regular hexagon (side a)	6a	$2{\cdot}598\ a^2$	Centre of figure
8. Regular heptagon (side a)	7a	$3{\cdot}634\ a^2$	Centre of figure
9. Regular octagon (side a)	8a	$4{\cdot}828\ a^2$	Centre of figure

7. Trignometric Functions

$$\sin \theta = \frac{a}{c}$$

$$\cos \theta = \frac{b}{c}$$

$$\tan \vartheta = \frac{a}{b}$$



8. Hyperbolic Functions

$$\sinh x = \frac{e^{x} - e^{-x}}{2}$$

$$\cosh x = \frac{e^{x} + e^{-x}}{2}$$

$$\tanh x = \frac{e^{x} - e^{-x}}{e^{x} + e^{-x}}$$

PART IV

Mathematical Tables

Logarithms

	0	1	2	3	4	5	6	7	8	9	Differences 1	2	3	4	5	6	7	8	9
10	0000	0043	0086	0128	0170	0212	0253	0294	0334	0374	4	8	12	17	21	25	29	33	37
11	0414	0453	0492	0531	0569	0607	0645	0682	0719	0755	4	8	11	15	19	23	26	30	34
12	0792	0828	0864	0899	0934	0969	1004	1038	1072	1106	3	7	10	14	17	21	24	28	31
13	1139	1173	1206	1239	1271	1303	1335	1367	1399	1430	3	6	10	13	16	19	23	26	29
14	1461	1492	1523	1553	1584	1614	1644	1673	1703	1732	3	6	9	12	15	18	21	24	27
15	1761	1790	1818	1847	1875	1903	1931	1959	1987	2014	3	6	8	11	14	17	20	22	25
16	2041	2068	2095	2122	2148	2175	2201	2227	2253	2279	3	5	8	11	13	16	18	21	24
17	2304	2330	2355	2380	2405	2430	2455	2480	2504	2529	2	5	7	10	12	15	17	20	22
18	2553	2577	2601	2625	2648	2672	2695	2718	2742	2765	2	5	7	9	12	14	16	19	21
19	2788	2810	2833	2856	2878	2900	2923	2945	2967	2989	2	4	7	9	11	13	16	18	20
20	3010	3032	3054	3075	3096	3118	3139	3160	3181	3201	2	4	6	8	11	13	15	17	19
21	3222	3243	3263	3284	3304	3324	3345	3365	3385	3404	2	4	6	8	10	12	14	16	18
22	3424	3444	3464	3483	3502	3522	3541	3560	3579	3598	2	4	6	8	10	12	14	15	17
23	3617	3636	3655	3674	3692	3711	3729	3747	3766	3784	2	4	6	7	9	11	13	15	17
24	3802	3820	3838	3856	3874	3892	3909	3927	3945	3962	2	4	5	7	9	11	12	14	16
25	3979	3997	4014	4031	4048	4065	4082	4099	4116	4133	2	3	5	7	9	10	12	14	15
26	4150	4166	4183	4200	4216	4232	4249	4265	4281	4298	2	3	5	7	8	10	11	13	15
27	4314	4330	4346	4362	4378	4393	4409	4425	4440	4456	2	3	5	6	8	9	11	13	14
28	4472	4487	4502	4518	4533	4548	4564	4579	4594	4609	2	3	5	6	8	9	11	12	14
29	4624	4639	4654	4669	4683	4698	4713	4728	4742	4757	1	3	4	6	7	9	10	12	13
30	4771	4786	4800	4814	4829	4843	4857	4871	4886	4900	1	3	4	6	7	9	10	11	13
31	4914	4928	4942	4955	4969	4983	4997	5011	5024	5038	1	3	4	6	7	8	10	11	12
32	5051	5065	5079	5092	5105	5119	5132	5145	5159	5172	1	3	4	5	7	8	9	11	12
33	5185	5198	5211	5224	5237	5250	5263	5276	5289	5302	1	3	4	5	6	8	9	10	12
34	5315	5328	5340	5353	5366	5378	5391	5403	5416	5428	1	3	4	5	6	8	9	10	11
35	5441	5453	5465	5478	5490	5502	5514	5527	5539	5551	1	2	4	5	6	7	9	10	11
36	5563	5575	5587	5599	5611	5623	5635	5647	5658	5670	1	2	4	5	6	7	8	10	11
37	5682	5694	5705	5717	5729	5740	5752	5763	5775	5786	1	2	3	5	6	7	8	9	10
38	5798	5809	5821	5832	5843	5855	5866	5877	5888	5899	1	2	3	5	6	7	8	9	10
39	5911	5922	5933	5944	5955	5966	5977	5988	5999	6010	1	2	3	4	5	7	8	9	10
40	6021	6031	6042	6053	6064	6075	6085	6096	6107	6117	1	2	3	4	5	6	8	9	10
41	6128	6138	6149	6160	6170	6180	6191	6201	6212	6222	1	2	3	4	5	6	7	8	9
42	6232	6243	6253	6263	6274	6284	6294	6304	6314	6325	1	2	3	4	5	6	7	8	9
43	6335	6345	6355	6365	6375	6385	6395	6405	6415	6425	1	2	3	4	5	6	7	8	9
44	6435	6444	6454	6464	6474	6484	6493	6503	6513	6522	1	2	3	4	5	6	7	8	9
45	6532	6542	6551	6561	6571	6580	6590	6599	6609	6618	1	2	3	4	5	6	7	8	9
46	6628	6637	6646	6656	6665	6675	6684	6693	6702	6712	1	2	3	4	5	6	7	7	8
47	6721	6730	6739	6749	6758	6767	6776	6785	6794	6803	1	2	3	4	5	5	6	7	8
48	6812	6821	6830	6839	6848	6857	6866	6875	6884	6893	1	2	3	4	4	5	6	7	8
49	6902	6911	6920	6928	6937	6946	6955	6964	6972	6981	1	2	3	4	4	5	6	7	8
50	6990	6998	7007	7016	7024	7033	7042	7050	7059	7067	1	2	3	3	4	5	6	7	8
51	7076	7084	7093	7101	7110	7118	7126	7135	7143	7152	1	2	3	3	4	5	6	7	8
52	7160	7168	7177	7185	7193	7202	7210	7218	7226	7235	1	2	2	3	4	5	6	7	7
53	7243	7251	7259	7267	7275	7284	7292	7300	7308	7316	1	2	2	3	4	5	6	6	7
54	7324	7332	7340	7348	7356	7364	7372	7380	7388	7396	1	2	2	3	4	5	6	6	7

Logarithms

											Differences								
	0	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9
55	7404	7412	7419	7427	7435	7443	7451	7459	7466	7474	1	2	2	3	4	5	5	6	7
56	7482	7490	7497	7505	7513	7520	7528	7536	7543	7551	1	2	2	3	4	5	5	6	7
57	7559	7566	7574	7582	7589	7597	7604	7612	7619	7627	1	2	2	3	4	5	5	6	7
58	7634	7642	7649	7657	7664	7672	7679	7686	7694	7701	1	1	2	3	4	4	5	6	7
59	7709	7716	7723	7731	7738	7745	7752	7760	7767	7774	1	1	2	3	4	4	5	6	7
60	7782	7789	7796	7803	7810	7818	7825	7832	7839	7846	1	1	2	3	4	4	5	6	6
61	7853	7860	7868	7875	7882	7889	7896	7903	7910	7917	1	1	2	3	4	4	5	6	6
62	7924	7931	7938	7945	7952	7959	7966	7973	7980	7987	1	1	2	3	3	4	5	6	6
63	7993	8000	8007	8014	8021	8028	8035	8041	8048	8055	1	1	2	3	3	4	5	5	6
64	8062	8069	8075	8082	8089	8096	8102	8109	8116	8122	1	1	2	3	3	4	5	5	6
65	8129	8136	8142	8149	8156	8162	8169	8176	8182	8189	1	1	2	3	3	4	5	5	6
66	8195	8202	8209	8215	8222	8228	8235	8241	8248	8254	1	1	2	3	3	4	5	5	6
67	8261	8267	8274	8280	8287	8293	8299	8306	8312	8319	1	1	2	3	3	4	5	5	6
68	8325	8331	8338	8344	8351	8357	8363	8370	8376	8382	1	1	2	3	3	4	4	5	6
69	8388	8395	8401	8407	8414	8420	8426	8432	8439	8445	1	1	2	2	3	4	4	5	6
70	8451	8457	8463	8470	8476	8482	8488	8494	8500	8506	1	1	2	2	3	4	4	5	6
71	8513	8519	8525	8531	8537	8543	8549	8555	8561	8567	1	1	2	2	3	4	4	5	5
72	8573	8579	8585	8591	8597	8603	8609	8615	8621	8627	1	1	2	2	3	4	4	5	5
73	8633	8639	8645	8651	8657	8663	8669	8675	8681	8686	1	1	2	2	3	4	4	5	5
74	8692	8698	8704	8710	8716	8722	8727	8733	8739	8745	1	1	2	2	3	4	4	5	5
75	8751	8756	8762	8768	8774	8779	8785	8791	8797	8802	1	1	2	2	3	3	4	5	5
76	8808	8814	8820	8825	8831	8837	8842	8848	8854	8859	1	1	2	2	3	3	4	5	5
77	8865	8871	8876	8882	8887	8893	8899	8904	8910	8915	1	1	2	2	3	3	4	4	5
78	8921	8927	8932	8938	8943	8949	8954	8960	8965	8971	1	1	2	2	3	3	4	4	5
79	8976	8982	8987	8993	8998	9004	9009	9015	9020	9025	1	1	2	2	3	3	4	4	5
80	9031	9036	9042	9047	9053	9058	9063	9069	9074	9079	1	1	2	2	3	3	4	4	5
81	9085	9090	9096	9101	9106	9112	9117	9122	9128	9133	1	1	2	2	3	3	4	4	5
82	9138	9143	9149	9154	9159	9165	9170	9175	9180	9186	1	1	2	2	3	3	4	4	5
83	9191	9196	9201	9206	9212	9217	9222	9227	9232	9238	1	1	2	2	3	3	4	4	5
84	9243	9248	9253	9258	9263	9269	9274	9279	9284	9289	1	1	2	2	3	3	4	4	5
85	9294	9299	9304	9309	9315	9320	9325	9330	9335	9340	1	1	2	2	3	3	4	4	5
86	9345	9350	9355	9360	9365	9370	9375	9380	9385	9390	1	1	2	2	3	3	4	4	5
87	9395	9400	9405	9410	9415	9420	9425	9430	9435	9440	0	1	1	2	2	3	3	4	4
88	9445	9450	9455	9460	9465	9469	9474	9479	9484	9489	0	1	1	2	2	3	3	4	4
89	9494	9499	9504	9509	9513	9518	9523	9528	9533	9538	0	1	1	2	2	3	3	4	4
90	9542	9547	9552	9557	9562	9566	9571	9576	9581	9586	0	1	1	2	2	3	3	4	4
91	9590	9595	9600	9605	9609	9614	9619	9624	9628	9633	0	1	1	2	2	3	3	4	4
92	9638	9643	9647	9652	9657	9661	9666	9671	9675	9680	0	1	1	2	2	3	3	4	4
93	9685	9689	9694	9699	9703	9708	9713	9717	9722	9727	0	1	1	2	2	3	3	4	4
94	9731	9736	9741	9745	9750	9754	9759	9763	9768	9773	0	1	1	2	2	3	3	4	4
95	9777	9782	9786	9791	9795	9800	9805	9809	9814	9818	0	1	1	2	2	3	3	4	4
96	9823	9827	9832	9836	9841	9845	9850	9854	9859	9863	0	1	1	2	2	3	3	4	4
97	9868	9872	9877	9881	9886	9890	9894	9899	9903	9908	0	1	1	2	2	3	3	4	4
98	9912	9917	9921	9926	9930	9934	9939	9943	9948	9952	0	1	1	2	2	3	3	4	4
99	9956	9961	9965	9969	9974	9978	9983	9987	9991	9996	0	1	1	2	2	3	3	3	4

Antilogarithms

	0	1	2	3	4	5	6	7	8	9	Differences 1	2	3	4	5	6	7	8	9
·00	1000	1002	1005	1007	1009	1012	1014	1016	1019	1021	0	0	1	1	1	1	2	2	2
·01	1023	1026	1028	1030	1033	1035	1038	1040	1042	1045	0	0	1	1	1	1	2	2	2
·02	1047	1050	1052	1054	1057	1059	1062	1064	1067	1069	0	0	1	1	1	1	2	2	2
·03	1072	1074	1076	1079	1081	1084	1086	1089	1091	1094	0	0	1	1	1	1	2	2	2
·04	1096	1099	1102	1104	1107	1109	1112	1114	1117	1119	0	1	1	1	1	2	2	2	2
·05	1122	1125	1127	1130	1132	1135	1138	1140	1143	1146	0	1	1	1	1	2	2	2	2
·06	1148	1151	1153	1156	1159	1161	1164	1167	1169	1172	0	1	1	1	1	2	2	2	2
·07	1175	1178	1180	1183	1186	1189	1191	1194	1197	1199	0	1	1	1	1	2	2	2	2
·08	1202	1205	1203	1211	1213	1216	1219	1222	1225	1227	0	1	1	1	1	2	2	2	3
·09	1230	1233	1236	1239	1242	1245	1247	1250	1253	1256	0	1	1	1	1	2	2	2	3
·10	1259	1262	1265	1268	1271	1274	1276	1279	1282	1285	0	1	1	1	1	2	2	2	3
·11	1288	1291	1294	1297	1300	1303	1306	1309	1312	1315	0	1	1	1	2	2	2	2	3
·12	1318	1321	1324	1327	1330	1334	1337	1340	1343	1346	0	1	1	1	2	2	2	2	3
·13	1349	1352	1355	1358	1361	1365	1368	1371	1374	1377	0	1	1	1	2	2	2	3	3
·14	1380	1384	1387	1390	1393	1396	1400	1403	1406	1409	0	1	1	1	2	2	2	3	3
·15	1413	1416	1419	1422	1426	1429	1432	1435	1439	1442	0	1	1	1	2	2	2	3	3
·16	1445	1449	1452	1455	1459	1462	1466	1469	1472	1476	0	1	1	1	2	2	2	3	3
·17	1479	1483	1486	1489	1493	1496	1500	1503	1507	1510	0	1	1	1	2	2	2	3	3
·18	1514	1517	1521	1524	1528	1531	1535	1538	1542	1545	0	1	1	1	2	2	2	3	3
·19	1549	1552	1556	1560	1563	1567	1570	1574	1578	1581	0	1	1	1	2	2	3	3	3
·20	1585	1589	1592	1596	1600	1603	1607	1611	1614	1618	0	1	1	1	2	2	3	3	3
·21	1622	1626	1629	1633	1637	1641	1644	1648	1652	1656	0	1	1	2	2	2	3	3	3
·22	1660	1663	1667	1671	1675	1679	1683	1687	1690	1694	0	1	1	2	2	2	3	3	3
·23	1698	1702	1706	1710	1714	1718	1722	1726	1730	1734	0	1	1	2	2	2	3	3	4
·24	1738	1742	1746	1750	1754	1758	1762	1766	1770	1774	0	1	1	2	2	2	3	3	4
·25	1778	1782	1786	1791	1795	1799	1803	1807	1811	1816	0	1	1	2	2	2	3	3	4
·26	1820	1824	1828	1832	1837	1841	1845	1849	1854	1858	0	1	1	2	2	3	3	3	4
·27	1862	1866	1871	1875	1879	1884	1888	1892	1897	1901	0	1	1	2	2	3	3	3	4
·28	1905	1910	1914	1919	1923	1928	1932	1936	1941	1945	0	1	1	2	2	3	3	4	4
·29	1950	1954	1959	1963	1968	1972	1977	1982	1986	1991	0	1	1	2	2	3	3	4	4
·30	1995	2000	2004	2009	2014	2018	2023	2028	2032	2037	0	1	1	2	2	3	3	4	4
·31	2042	2046	2051	2056	2061	2065	2070	2075	2080	2084	0	1	1	2	2	3	3	4	4
·32	2089	2094	2099	2104	2109	2113	2118	2123	2128	2133	0	1	1	2	2	3	3	4	4
·33	2138	2143	2148	2153	2158	2163	2168	2173	2178	2183	0	1	1	2	2	3	3	4	4
·34	2188	2193	2198	2203	2208	2213	2218	2223	2228	2234	1	1	2	2	3	3	4	4	5
·35	2239	2244	2249	2254	2259	2265	2270	2275	2280	2286	1	1	2	2	3	3	4	4	5
·36	2291	2296	2301	2307	2312	2317	2323	2328	2333	2339	1	1	2	2	3	3	4	4	5
·37	2344	2350	2355	2360	2366	2371	2377	2382	2388	2393	1	1	2	2	3	3	4	4	5
·38	2399	2404	2410	2415	2421	2427	2432	2438	2443	2449	1	1	2	2	3	3	4	4	5
·39	2455	2460	2466	2472	2477	2483	2489	2495	2500	2506	1	1	2	2	3	3	4	5	5
·40	2512	2518	2523	2529	2535	2541	2547	2553	2559	2564	1	1	2	2	3	4	4	5	5
·41	2570	2576	2582	2588	2594	2600	2606	2612	2618	2624	1	1	2	2	3	4	4	5	5
·42	2630	2636	2642	2649	2655	2661	2667	2673	2679	2685	1	1	2	2	3	4	4	5	6
·43	2692	2698	2704	2710	2716	2723	2729	2735	2742	2748	1	1	2	3	3	4	4	5	6
·44	2754	2761	2767	2773	2780	2786	2793	2799	2805	2812	1	1	2	3	3	4	4	5	6
·45	2818	2825	2831	2838	2844	2851	2858	2864	2871	2877	1	1	2	3	3	4	4	5	6
·46	2884	2891	2897	2904	2911	2917	2924	2931	2938	2944	1	1	2	3	3	4	5	5	6
·47	2951	2958	2965	2972	2979	2985	2992	2999	3006	3013	1	1	2	3	3	4	5	5	6
·48	3020	3027	3034	3041	3048	3055	3062	3069	3076	3083	1	1	2	3	4	4	5	6	6
·49	3090	3097	3105	3112	3119	3126	3133	3141	3148	3155	1	1	2	3	4	4	5	6	6

NATURAL LOGARITHMS OF 10^n

n	1	2	3	4	5	6	7	8	9
$\log_e 10^n$	2·3026	4·6052	6·9078	9·2103	11·5129	13·8155	16·1181	18·4207	20·7233

e.g. $\log_e 345{\cdot}6 = \log_e(3{\cdot}456 \times 10^2) = 1{\cdot}2401 + 4{\cdot}6052 = 5{\cdot}8453$

Antilogarithms

	0	1	2	3	4	5	6	7	8	9	Differences								
											1	2	3	4	5	6	7	8	9
·50	3162	3170	3177	3184	3192	3199	3206	3214	3221	3228	1	1	2	3	4	4	5	6	7
·51	3236	3243	3251	3258	3266	3273	3281	3289	3296	3304	1	2	2	3	4	5	5	6	7
·52	3311	3319	3327	3334	3342	3350	3357	3365	3373	3381	1	2	2	3	4	5	5	6	7
·53	3388	3396	3404	3412	3420	3428	3436	3443	3451	3459	1	2	2	3	4	5	6	6	7
·54	3467	3475	3483	3491	3499	3508	3516	3524	3532	3540	1	2	2	3	4	5	6	6	7
·55	3548	3556	3565	3573	3581	3589	3597	3606	3614	3622	1	2	2	3	4	5	6	7	7
·56	3631	3639	3648	3656	3664	3673	3681	3690	3698	3707	1	2	3	3	4	5	6	7	8
·57	3715	3724	3733	3741	3750	3758	3767	3776	3784	3793	1	2	3	3	4	5	6	7	8
·58	3802	3811	3819	3828	3837	3846	3855	3864	3873	3882	1	2	3	4	4	5	6	7	8
·59	3890	3899	3908	3917	3926	3936	3945	3954	3963	3972	1	2	3	4	5	5	6	7	8
·60	3981	3990	3999	4009	4018	4027	4036	4046	4055	4064	1	2	3	4	5	6	6	7	8
·61	4074	4083	4093	4102	4111	4121	4130	4140	4150	4159	1	2	3	4	5	6	7	8	9
·62	4169	4178	4188	4198	4207	4217	4227	4236	4246	4256	1	2	3	4	5	6	7	8	9
·63	4266	4276	4285	4295	4305	4315	4325	4335	4345	4355	1	2	3	4	5	6	7	8	9
·64	4365	4375	4385	4395	4406	4416	4426	4436	4446	4457	1	2	3	4	5	6	7	8	9
·65	4467	4477	4487	4498	4508	4519	4529	4539	4550	4560	1	2	3	4	5	6	7	8	9
·66	4571	4581	4592	4603	4613	4624	4634	4645	4656	4667	1	2	3	4	5	6	7	9	10
·67	4677	4688	4699	4710	4721	4732	4742	4753	4764	4775	1	2	3	4	5	7	8	9	10
·68	4786	4797	4808	4819	4831	4842	4853	4864	4875	4887	1	2	3	4	6	7	8	9	10
·69	4898	4909	4920	4932	4943	4955	4966	4977	4989	5000	1	2	3	5	6	7	8	9	10
·70	5012	5023	5035	5047	5058	5070	5082	5093	5105	5117	1	2	4	5	6	7	8	9	10
·71	5129	5140	5152	5164	5176	5188	5200	5212	5224	5236	1	2	4	5	6	7	8	10	11
·72	5248	5260	5272	5284	5297	5309	5321	5333	5346	5358	1	2	4	5	6	7	9	10	11
·73	5370	5383	5395	5408	5420	5433	5445	5458	5470	5483	1	3	4	5	6	8	9	10	11
·74	5495	5508	5521	5534	5546	5559	5572	5585	5598	5610	1	3	4	5	6	8	9	10	12
·75	5623	5636	5649	5662	5675	5689	5702	5715	5728	5741	1	3	4	5	7	8	9	10	12
·76	5754	5768	5781	5794	5808	5821	5834	5848	5861	5875	1	3	4	5	7	8	9	11	12
·77	5888	5902	5916	5929	5943	5957	5970	5984	5998	6012	1	3	4	5	7	8	10	11	12
·78	6026	6039	6053	6067	6081	6095	6109	6124	6138	6152	1	3	4	6	7	8	10	11	13
·79	6166	6180	6194	6209	6223	6237	6252	6266	6281	6295	1	3	4	6	7	9	10	11	13
·80	6310	6324	6339	6353	6368	6383	6397	6412	6427	6442	1	3	4	6	7	9	10	12	13
·81	6457	6471	6486	6501	6516	6531	6546	6561	6577	6592	2	3	5	6	8	9	11	12	14
·82	6607	6622	6637	6653	6668	6683	6699	6714	6730	6745	2	3	5	6	8	9	11	12	14
·83	6761	6776	6792	6808	6823	6839	6855	6871	6887	6902	2	3	5	6	8	9	11	13	14
·84	6918	6934	6950	6966	6982	6998	7015	7031	7047	7063	2	3	5	6	8	10	11	13	15
·85	7079	7096	7112	7129	7145	7161	7178	7194	7211	7228	2	3	5	7	8	10	12	13	15
·86	7244	7261	7278	7295	7311	7328	7345	7362	7379	7396	2	3	5	7	8	10	12	13	15
·87	7413	7430	7447	7464	7482	7499	7516	7534	7551	7568	2	3	5	7	9	10	12	14	16
·88	7586	7603	7621	7638	7656	7674	7691	7709	7727	7745	2	4	5	7	9	11	12	14	16
·89	7762	7780	7798	7816	7834	7852	7870	7889	7907	7925	2	4	5	7	9	11	13	14	16
·90	7943	7962	7980	7998	8017	8035	8054	8072	8091	8110	2	4	6	7	9	11	13	15	17
·91	8128	8147	8166	8185	8204	8222	8241	8260	8279	8299	2	4	6	8	9	11	13	15	17
·92	8318	8337	8356	8375	8395	8414	8433	8453	8472	8492	2	4	6	8	10	12	14	15	17
·93	8511	8531	8551	8570	8590	8610	8630	8650	8670	8690	2	4	6	8	10	12	14	16	18
·94	8710	8730	8750	8770	8790	8810	8831	8851	8872	8892	2	4	6	8	10	12	14	16	18
·95	8913	8933	8954	8974	8995	9016	9036	9057	9078	9099	2	4	6	8	10	12	15	17	19
·96	9120	9141	9162	9183	9204	9226	9247	9268	9290	9311	2	4	6	8	11	13	15	17	19
·97	9333	9354	9376	9397	9419	9441	9462	9484	9506	9528	2	4	7	9	11	13	15	17	20
·98	9550	9572	9594	9616	9638	9661	9683	9705	9727	9750	2	4	7	9	11	13	16	18	20
·99	9772	9795	9817	9840	9863	9886	9908	9931	9954	9977	2	5	7	9	11	14	16	18	20

NATURAL LOGARITHMS OF 10^{-n}

n	1	2	3	4	5	6	7	8	9
$\log_e 10^{-n}$	$\bar{3}\cdot6974$	$\bar{5}\cdot3948$	$\bar{7}\cdot0922$	$\bar{10}\cdot7897$	$\bar{12}\cdot4871$	$\bar{14}\cdot1845$	$\bar{17}\cdot8819$	$\bar{19}\cdot5793$	$\bar{21}\cdot2767$

e.g. $\log_e 0\cdot103\,456 = \log_e(3\cdot456 \times 12^{-2}) = 1\cdot2401 + \bar{5}\cdot3948$

Natural Sines

Deg	0′	5′	10′	15′	20′	25′	30′	35′	40′	45′	50′	55′	Mean differences 1′	2′	3′	4′
0	0·0000	·0015	·0029	·0044	·0058	·0073	·0087	·0102	·0116	·0131	·0145	·0160	3	6	9	12
1	·0175	·0189	·0204	·0218	·0233	·0247	·0262	·0276	·0291	·0305	·0320	·0334	3	6	9	12
2	·0349	·0364	·0378	·0393	·0407	·0422	·0436	·0451	·0465	·0480	·0494	·0509	3	6	9	12
3	·0523	·0538	·0552	·0567	·0581	·0596	·0610	·0625	·0640	·0654	·0669	·0683	3	6	9	12
4	·0698	·0712	·0727	·0741	·0756	·0770	·0785	·0799	·0814	·0828	·0843	·0857	3	6	9	12
5	·0872	·0886	·0901	·0915	·0929	·0944	·0958	·0973	·0987	·1002	·1016	·1031	3	6	9	12
6	·1045	·1060	·1074	·1089	·1103	·1118	·1132	·1146	·1161	·1175	·1190	·1204	3	6	9	12
7	·1219	·1233	·1248	·1262	·1276	·1291	·1305	·1320	·1334	·1349	·1363	·1377	3	6	9	12
8	·1392	·1406	·1421	·1435	·1449	·1464	·1478	·1492	·1507	·1521	·1536	·1550	3	6	9	12
9	·1564	·1579	·1593	·1607	·1622	·1636	·1650	·1665	·1679	·1693	·1708	·1722	3	6	9	11
10	·1736	·1751	·1765	·1779	·1794	·1808	·1822	·1837	·1851	·1865	·1880	·1894	3	6	9	11
11	·1908	·1922	·1937	·1951	·1965	·1979	·1994	·2008	·2022	·2036	·2051	·2065	3	6	9	11
12	·2079	·2093	·2108	·2122	·2136	·2150	·2164	·2179	·2193	·2207	·2221	·2235	3	6	9	11
13	·2250	·2264	·2278	·2292	·2306	·2320	·2334	·2349	·2363	·2377	·2391	·2405	3	6	8	11
14	·2419	·2433	·2447	·2462	·2476	·2490	·2504	·2518	·2532	·2546	·2560	·2574	3	6	8	11
15	·2588	·2602	·2616	·2630	·2644	·2658	·2672	·2686	·2700	·2714	·2728	·2742	3	6	8	11
16	·2756	·2770	·2784	·2798	·2812	·2826	·2840	·2854	·2868	·2882	·2896	·2910	3	6	8	11
17	·2924	·2938	·2952	·2965	·2979	·2993	·3007	·3021	·3035	·3049	·3062	·3076	3	6	8	11
18	·3090	·3104	·3118	·3132	·3145	·3159	·3173	·3187	·3201	·3214	·3228	·3242	3	6	8	11
19	·3256	·3269	·3283	·3297	·3311	·3324	·3338	·3352	·3365	·3379	·3393	·3407	3	5	8	11
20	·3420	·3434	·3448	·3461	·3475	·3488	·3502	·3516	·3529	·3543	·3557	3570	3	5	8	11
21	·3584	·3597	·3611	·3624	·3638	·3651	·3665	·3679	·3692	·3706	·3719	·3733	3	5	8	11
22	·3746	·3760	·3773	·3786	·3800	·3813	·3827	·3840	·3854	·3867	·3881	·3894	3	5	8	11
23	·3907	·3921	·3934	·3947	·3961	·3974	·3987	·4001	·4014	·4027	·4041	·4054	3	5	8	11
24	·4067	·4081	·4094	·4107	·4120	·4134	·4147	·4160	·4173	·4187	·4200	·4213	3	5	8	11
25	·4226	·4239	·4253	·4266	·4279	·4292	·4305	·4318	·4331	·4344	·4358	·4371	3	5	8	10
26	·4384	·4397	·4410	·4423	·4436	·4449	·4462	·4475	·4488	·4501	·4514	·4527	3	5	8	10
27	·4540	·4553	·4566	·4579	·4592	·4605	·4617	·4630	·4643	·4656	·4669	·4682	3	5	8	10
28	·4695	·4708	·4720	·4733	·4746	·4759	·4772	·4784	·4797	·4810	·4823	·4835	3	5	8	10
29	·4848	·4861	·4874	·4886	·4899	·4912	·4924	·4937	·4950	·4962	·4975	·4987	3	5	8	10
30	·5000	·5013	·5025	·5038	·5050	·5063	·5075	·5088	·5100	·5113	·5125	·5138	3	5	8	10
31	·5150	·5163	·5175	·5188	·5200	·5213	·5225	·5237	·5250	·5262	·5275	·5287	2	5	7	10
32	·5299	·5312	·5324	·5336	·5348	·5361	·5373	·5385	·5398	·5410	·5422	·5434	2	5	7	10
33	·5446	·5459	·5471	·5483	·5495	·5507	·5519	·5531	·5544	·5556	·5568	·5580	2	5	7	10
34	·5592	·5604	·5616	·5628	·5640	·5652	·5664	·5676	·5688	·5700	·5712	·5724	2	5	7	10
35	·5736	·5748	·5760	·5771	·5783	·5795	·5807	·5819	·5831	·5842	·5854	·5866	2	5	7	9
36	·5878	·5890	·5901	·5913	·5925	·5937	·5948	·5960	·5972	·5983	·5995	·6007	2	5	7	9
37	·6018	·6030	·6041	·6053	·6065	·6076	·6088	·6099	·6111	·6122	·6134	·6145	2	5	7	9
38	·6157	·6168	·6180	·6191	·6202	·6214	·6225	·6237	·6248	·6259	·6271	·6282	2	5	7	9
39	·6293	·6305	·6316	·6327	·6338	·6350	·6361	·6372	·6383	·6394	·6406	·6417	2	4	7	9
40	·6428	·6439	·6450	·6461	·6472	·6483	·6494	·6506	·6517	·6528	·6539	·6550	2	4	7	9
41	·6561	·6572	·6583	·6593	·6604	·6615	·6626	·6637	·6648	·6659	·6670	·6680	2	4	7	9
42	·6691	·6702	·6713	·6724	·6734	·6745	·6756	·6767	·6777	·6788	·6799	·6809	2	4	6	9
43	·6820	·6831	·6841	·6852	·6862	·6873	·6884	·6894	·6905	·6915	·6926	·6936	2	4	6	8
44	·6947	·6957	·6967	·6978	·6988	·6999	·7009	·7019	·7030	·7040	·7050	·7061	2	4	6	8

Natural Sines

Deg	0′	5′	10′	15′	20′	25′	30′	35′	40′	45′	50′	55′	Mean differences			
													1′	2′	3′	4′
45	·7071	·7081	·7092	·7102	·7112	·7122	·7133	·7143	·7153	·7163	·7173	·7183	2	4	6	8
46	·7193	·7203	·7214	·7224	·7234	·7244	·7254	·7264	·7274	·7284	·7294	·7304	2	4	6	8
47	·7314	·7323	·7333	·7343	·7353	·7363	·7373	·7383	·7392	·7402	·7412	·7422	2	4	6	8
48	·7431	·7441	·7451	·7461	·7470	·7480	·7490	·7499	·7509	·7518	·7528	·7538	2	4	6	8
49	·7547	·7557	·7566	·7576	·7585	·7595	·7604	·7613	·7623	·7632	·7642	·7651	2	4	6	8
50	·7660	·7670	·7679	·7688	·7698	·7707	·7716	·7725	·7735	·7744	·7753	·7762	2	4	6	7
51	·7771	·7781	·7790	·7799	·7808	·7817	·7826	·7835	·7844	·7853	·7862	·7871	2	4	5	7
52	·7880	·7889	·7898	·7907	·7916	·7925	·7934	·7942	·7951	·7960	·7969	·7978	2	4	5	7
53	·7986	·7995	·8004	·8013	·8021	·8030	·8039	·8047	·8056	·8064	·8073	·8082	2	3	5	7
54	·8090	·8099	·8107	·8116	·8124	·8133	·8141	·8150	·8158	·8166	·8175	·8183	2	3	5	7
55	·8192	·8200	·8208	·8216	·8225	·8233	·8241	·8249	·8258	·8266	·8274	·8282	2	3	5	7
56	·8290	·8298	·8307	·8315	·8323	·8331	·8339	·8347	·8355	·8363	·8371	·8379	2	3	5	6
57	·8387	·8395	·8403	·8410	·8418	·8426	·8434	·8442	·8450	·8457	·8465	·8473	2	3	5	6
58	·8480	·8488	·8496	·8504	·8511	·8519	·8526	·8534	·8542	·8549	·8557	·8564	2	3	5	6
59	·8572	·8579	·8587	·8594	·8601	·8609	·8616	·8624	·8631	·8638	·8646	·8653	1	3	4	6
60	·8660	·8668	·8675	·8682	·8689	·8696	·8704	·8711	·8718	·8725	·8732	·8739	1	3	4	6
61	·8746	·8753	·8760	·8767	·8774	·8781	·8788	·8795	·8802	·8809	·8816	·8823	1	3	4	6
62	·8829	·8836	·8843	·8850	·8857	·8863	·8870	·8877	·8884	·8890	·8897	·8903	1	3	4	5
63	·8910	·8917	·8923	·8930	·8936	·8943	·8949	·8956	·8962	·8969	·8975	·8982	1	3	4	5
64	·8988	·8994	·9001	·9007	·9013	·9020	·9026	·9032	·9038	·9045	·9051	·9057	1	3	4	5
65	·9063	·9069	·9075	·9081	·9088	·9094	·9100	·9106	·9112	·9118	·9124	·9130	1	2	4	5
66	·9135	·9141	·9147	·9153	·9159	·9165	·9171	·9176	·9182	·9188	·9194	·9199	1	2	3	5
67	·9205	·9211	·9216	·9222	·9228	·9233	·9239	·9244	·9250	·9255	·9261	·9266	1	2	3	4
68	·9272	·9277	·9283	·9288	·9293	·9299	·9304	·9309	·9315	·9320	·9325	·9331	1	2	3	4
69	·9336	·9341	·9346	·9351	·9356	·9362	·9367	·9372	·9377	·9382	·9387	·9392	1	2	3	4
70	·9397	·9402	·9407	·9412	·9417	·9422	·9426	·9431	·9436	·9441	·9446	·9450	1	2	3	4
71	·9455	·9460	·9465	·9469	·9474	·9479	·9483	·9488	·9492	·9497	·9502	·9506	1	2	3	4
72	·9511	·9515	·9520	·9524	·9528	·9533	·9537	·9542	·9546	·9550	·9555	·9559	1	2	3	3
73	·9563	·9567	·9572	·9576	·9580	·9584	·9588	·9592	·9596	·9600	·9605	·9609	1	2	2	3
74	·9613	·9617	·9621	·9625	·9628	·9632	·9636	·9640	·9644	·9648	·9652	·9655	1	2	2	3
75	·9659	·9663	·9667	·9670	·9674	·9678	·9681	·9685	·9689	·9692	·9696	·9699	1	1	2	3
76	·9703	·9706	·9710	·9713	·9717	·9720	·9724	·9727	·9730	·9734	·9737	·9740	1	1	2	3
77	·9744	·9747	·9750	·9753	·9757	·9760	·9763	·9766	·9769	·9772	·9775	·9778	1	1	2	3
78	·9781	·9784	·9787	·9790	·9793	·9796	·9799	·9802	·9805	·9808	·9811	·9813	1	1	2	2
79	·9816	·9819	·9822	·9825	·9827	·9830	·9833	·9835	·9838	·9840	·9843	·9846	1	1	2	2
80	·9848	·9851	·9853	·9856	·9858	·9860	·9863	·9865	·9868	·9870	·9872	·9875	0	1	1	2
81	·9877	·9879	·9881	·9884	·9886	·9888	·9890	·9892	·9894	·9897	·9899	·9901	0	1	1	2
82	·9903	·9905	·9907	·9909	·9911	·9913	·9914	·9916	·9918	·9920	·9922	·9924	0	1	1	2
83	·9925	·9927	·9929	·9931	·9932	·9934	·9936	·9937	·9939	·9941	·9942	·9944	0	1	1	1
84	·9945	·9947	·9948	·9950	·9951	·9953	·9954	·9955	·9957	·9958	·9959	·9961	0	1	1	1
85	·9962	·9963	·9964	·9966	·9967	·9968	·9969	·9970	·9981	·9973	·9974	·9975	0	0	1	1
86	·9976	·9977	·9978	·9979	·9980	·9980	·9981	·9982	·9983	·9984	·9985	·9986	0	0	1	1
87	·9986	·9987	·9988	·9988	·9989	·9990	·9990	·9991	·9992	·9992	·9993	·9993	0	0	0	1
88	·9994	·9994	·9995	·9995	·9996	·9996	·9997	·9997	·9997	·9998	·9998	·9998	0	0	0	0
89	·9998	·9999	·9999	·9999	·9999	·9999	1·0000	1·0000	1·0000	1·0000	1·0000	1·0000	0	0	0	0

Logarithms of Sines

Deg	0′	5′	10′	15′	20′	25′	30′	35′	40′	45′	50′	55′	Mean differences			
													1′	2′	3′	4′
0	– ∞	$\bar{3}$ 1627	4637	6398	7648	8617	9408	0078*	0658	1169	1627	2041				
1	$\bar{2}$·2419	2766	3088	3388	3668	3931	4179	4414	4637	4848	5050	5243				
2	$\bar{2}$·5428	5605	5776	5939	6097	6250	6397	6539	6677	6810	6940	7066				
3	$\bar{2}$·7188	7307	7423	7535	7645	7752	7857	7959	8059	8156	8251	8345				
4	$\bar{2}$·8436	8525	8613	8699	8783	8865	8946	9026	9104	9181	9256	9330	16	32	48	64
5	$\bar{2}$·9403	9475	9545	9614	9682	9750	9816	9881	9945	0008*	0070	0132	13	26	39	52
6	$\bar{1}$·0192	0252	0311	0369	0426	0483	0539	0594	0648	0702	0755	0807	11	22	33	44
7	$\bar{1}$·0859	0910	0961	1011	1060	1109	1157	1205	1252	1299	1345	1390	10	19	29	38
8	$\bar{1}$·1436	1480	1525	1568	1612	1655	1697	1739	1781	1822	1863	1903	8	17	25	34
9	$\bar{1}$·1943	1983	2022	2061	2100	2138	2176	2214	2251	2288	2324	2361	8	15	23	30
10	$\bar{1}$·2397	2432	2468	2503	2538	2572	2606	2640	2674	2707	2740	2773	7	14	20	27
11	$\bar{1}$·2806	2838	2870	2902	2934	2965	2997	3027	3058	3089	3119	3149	6	12	19	25
12	$\bar{1}$·3179	3208	3238	3267	3296	3325	3353	3382	3410	3438	3466	3493	6	11	17	23
13	$\bar{1}$·3521	3548	3575	3602	3629	3655	3682	3708	3734	3760	3786	3811	5	11	16	21
14	$\bar{1}$·3837	3862	3887	3912	3937	3961	3986	4010	4035	4059	4083	4106	5	10	15	19
15	$\bar{1}$·4130	4153	4177	4200	4223	4246	4269	4292	4314	4337	4359	4381	5	9	14	18
16	$\bar{1}$·4403	4425	4447	4469	4491	4512	4533	4555	4576	4597	4618	4639	4	9	13	17
17	$\bar{1}$·4659	4680	4700	4721	4741	4761	4781	4801	4821	4841	4861	4880	4	8	12	16
18	$\bar{1}$·4900	4919	4939	4958	4977	4996	5015	5034	5052	5071	5090	5108	4	8	11	15
19	$\bar{1}$·5126	5145	5163	5181	5199	5217	5235	5253	5270	5288	5306	5323	4	7	11	14
20	$\bar{1}$·5341	5358	5375	5392	5409	5426	5443	5460	5477	5494	5510	5527	3	7	10	13
21	$\bar{1}$·5543	5560	5576	5592	5609	5625	5641	5657	5673	5689	5704	5720	3	6	10	13
22	$\bar{1}$·5736	5751	5767	5782	5798	5813	5828	5844	5859	5874	5889	5904	3	6	9	12
23	$\bar{1}$·5919	5934	5948	5963	5978	5992	6007	6021	6036	6050	6065	6079	3	6	9	12
24	$\bar{1}$·6093	6107	6121	6135	6149	6163	6177	6191	6205	6219	6232	6246	3	6	8	11
25	$\bar{1}$·6259	6273	6286	6300	6313	6327	6340	6353	6366	6379	6392	6405	3	5	8	11
26	$\bar{1}$·6418	6431	6444	6457	6470	6483	6495	6508	6521	6533	6546	6558	3	5	8	10
27	$\bar{1}$·6570	6583	6595	6607	6620	6632	6644	6656	6668	6680	6692	6704	2	5	7	10
28	$\bar{1}$·6716	6728	6740	6752	6763	6775	6787	6798	6810	6821	6833	6844	2	5	7	9
29	$\bar{1}$·6856	6867	6878	6890	6901	6912	6923	6935	6946	6957	6968	6979	2	4	7	9
30	$\bar{1}$·6990	7001	7012	7022	7033	7044	7055	7065	7076	7087	7097	7108	2	4	6	9
31	$\bar{1}$·7118	7129	7139	7150	7160	7171	7181	7191	7201	7212	7222	7232	2	4	6	8
32	$\bar{1}$·7242	7252	7262	7272	7282	7292	7302	7312	7322	7332	7342	7351	2	4	6	8
33	$\bar{1}$·7361	7371	7380	7390	7400	7409	7419	7428	7438	7447	7457	7466	2	4	6	8
34	$\bar{1}$·7476	7485	7494	7504	7513	7522	7531	7540	7550	7559	7568	7577	2	4	6	7
35	$\bar{1}$·7586	7595	7604	7613	7622	7631	7640	7648	7657	7666	7675	7683	2	4	5	7
36	$\bar{1}$·7692	7701	7710	7718	7727	7735	7744	7752	7761	7769	7778	7786	2	3	5	7
37	$\bar{1}$·7795	7803	7811	7820	7828	7836	7844	7853	7861	7869	7877	7885	2	3	5	7
38	$\bar{1}$·7893	7901	7910	7918	7926	7934	7941	7949	7957	7965	7973	7981	2	3	5	6
39	$\bar{1}$·7989	7997	8004	8012	8020	8027	8035	8043	8050	8058	8066	8073	2	3	5	6
40	$\bar{1}$·8081	8088	8096	8103	8111	8118	8125	8133	8140	8148	8155	8162	1	3	4	6
41	$\bar{1}$·8169	8177	8184	8191	8198	8205	8213	8220	8227	8234	8241	8248	1	3	4	6
42	$\bar{1}$·8255	8262	8269	8276	8283	8290	8297	8304	8311	8317	8324	8331	1	3	4	5
43	$\bar{1}$·8338	8345	8351	8358	8365	8371	8378	8385	8391	8398	8405	8411	1	3	4	5
44	$\bar{1}$·8418	8424	8431	8437	8444	8450	8457	8463	8469	8476	8482	8489	1	3	4	

* Indicates that the characteristic is increased by one.

Logarithms of Sines

													Mean differences			
Deg	0′	5′	10′	15′	20′	25′	30′	35′	40′	45′	50′	55′	1′	2′	3′	4′
45	$\bar{1}$·8495	8501	8507	8514	8520	8526	8532	8539	8545	8551	8557	8563	1	2	4	5
46	$\bar{1}$·8569	8575	8582	8588	8594	8600	8606	8612	8618	8624	8629	8635	1	2	4	5
47	$\bar{1}$·8641	8647	8653	8659	8665	8671	8676	8682	8688	8694	8699	8705	1	2	3	5
48	$\bar{1}$·8711	8716	8722	8728	8733	8739	8745	8750	8756	8761	8767	8772	1	2	3	4
49	$\bar{1}$·8778	8783	8789	8794	8800	8805	8810	8816	8821	8827	8832	8837	1	2	3	4
50	$\bar{1}$·8843	8848	8853	8858	8864	8869	8874	8879	8884	8890	8895	8900	1	2	3	4
51	$\bar{1}$·8905	8910	8915	8920	8925	8930	8935	8940	8945	8950	8955	8960	1	2	3	4
52	$\bar{1}$·8965	8970	8975	8980	8985	8990	8995	9000	9004	9009	9014	9019	1	2	3	4
53	$\bar{1}$·9023	9028	9033	9038	9042	9047	9052	9056	9061	9066	9070	9075	1	2	3	4
54	$\bar{1}$·9080	9084	9089	9093	9098	9102	9107	9111	9116	9120	9125	9129	1	2	3	4
55	$\bar{1}$·9134	9138	9142	9147	9151	9156	9160	9164	9169	9173	9177	9181	1	2	3	3
56	$\bar{1}$·9186	9190	9194	9198	9203	9207	9211	9215	9219	9224	9228	9232	1	2	3	3
57	$\bar{1}$·9236	9240	9244	9248	9252	9256	9260	9264	9268	9272	9276	9280	1	2	2	3
58	$\bar{1}$·9284	9288	9292	9296	9300	9304	9308	9312	9315	9319	9323	9327	1	2	2	3
59	$\bar{1}$·9331	9334	9338	9342	9346	9349	9353	9357	9361	9364	9368	9372	1	1	2	3
60	$\bar{1}$·9375	9379	9383	9386	9390	9393	9397	9401	9404	9408	9411	9415	1	1	2	3
61	$\bar{1}$·9418	9422	9425	9429	9432	9436	9439	9442	9446	9449	9453	9456	1	1	2	3
62	$\bar{1}$·9459	9463	9466	9469	9473	9476	9479	9483	9486	9489	9492	9496	1	1	2	3
63	$\bar{1}$·9499	9502	9505	9508	9512	9515	9518	9521	9524	9527	9530	9534	1	1	2	3
64	$\bar{1}$·9537	9540	9543	9546	9549	9552	9555	9558	9561	9564	9567	9570	1	1	2	2
65	$\bar{1}$·9573	9576	9579	9582	9584	9587	9590	9593	9596	9599	9602	9604	1	1	2	2
66	$\bar{1}$·9607	9610	9613	9616	9618	9621	9624	9627	9629	9632	9635	9638	1	1	2	2
67	$\bar{1}$·9640	9643	9646	9648	9651	9654	9656	9659	9661	9664	9667	9669	1	1	2	2
68	$\bar{1}$·9672	9674	9677	9679	9682	9684	9687	9689	9692	9694	9697	9699	0	1	1	2
69	$\bar{1}$·9702	9704	9706	9709	9711	9714	9716	9718	9721	9723	9725	9728	0	1	1	2
70	$\bar{1}$·9730	9732	9734	9737	9739	9741	9743	9746	9748	9750	9752	9755	0	1	1	2
71	$\bar{1}$·9757	9759	9761	9763	9765	9767	9770	9772	9774	9776	9778	9780	0	1	1	2
72	$\bar{1}$·9782	9784	9786	9788	9790	9792	9794	9796	9798	9800	9802	9804	0	1	1	2
73	$\bar{1}$·9806	9808	9810	9812	9814	9815	9817	9819	9821	9823	9825	9827	0	1	1	1
74	$\bar{1}$·9828	9830	9832	9834	9836	9837	9839	9841	9843	9844	9846	9848	0	1	1	1
75	$\bar{1}$·9849	9851	9853	9854	9856	9858	9859	9861	9863	9864	9866	9867	0	1	1	1
76	$\bar{1}$·9869	9871	9872	9874	9875	9877	9878	9880	9881	9883	9884	9886	0	1	1	1
77	$\bar{1}$·9887	9889	9890	9892	9893	9894	9896	9897	9899	9900	9901	9903	0	1	1	1
78	$\bar{1}$·9904	9905	9907	9908	9909	9911	9912	9913	9914	9916	9917	9918	0	1	1	1
79	$\bar{1}$·9919	9921	9922	9923	9924	9925	9927	9928	9929	9930	9931	9932	0	0	1	1
80	$\bar{1}$·9934	9935	9936	9937	9938	9939	9940	9941	9942	9943	9944	9945	0	0	1	1
81	$\bar{1}$·9946	9947	9948	9949	9950	9951	9952	9953	9954	9955	9956	9957	0	0	1	1
82	$\bar{1}$·9958	9958	9959	9960	9961	9962	9963	9964	9964	9965	9966	9967	0	0	0	1
83	$\bar{1}$·9968	9968	9969	9970	9971	9971	9972	9973	9973	9974	9975	9975	0	0	0	1
84	$\bar{1}$·9976	9977	9977	9978	9979	9979	9980	9981	9981	9982	9982	9983	0	0	0	0
85	$\bar{1}$·9983	9984	9985	9985	9986	9986	9987	9987	9988	9988	9989	9989	0	0	0	0
86	$\bar{1}$·9989	9990	9990	9991	9991	9992	9992	9992	9993	9993	9993	9994	0	0	0	0
87	$\bar{1}$·9994	9994	9995	9995	9995	9996	9996	9996	9996	9997	9997	9997	0	0	0	0
88	$\bar{1}$·9997	9998	9998	9998	9998	9998	9999	9999	9999	9999	9999	9999	0	0	0	0
89	$\bar{1}$·9999	9999	0000*	0000	0000	0000	0000	0000	0000	0000	0000	0000	0	0	0	0

* Indicates that the characteristic is increased by one.

Natural Cosines

Deg	0′	5′	10′	15′	20′	25′	30′	35′	40′	45′	50′	55′	Mean differences to be subtracted			
													1′	2′	3′	4′
0	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	·9999	·9999	·9999	·9999	·9999	0	0	0	0
1	·9998	·9998	·9998	·9998	·9997	·9997	·9997	·9996	·9996	·9995	·9995	·9994	0	0	0	0
2	·9994	·9993	·9993	·9992	·9992	·9991	·9990	·9990	·9989	·9988	·9988	·9987	0	0	0	1
3	·9986	·9986	·9985	·9984	·9983	·9982	·9981	·9980	·9980	·9979	·9978	·9977	0	0	1	1
4	·9976	·9975	·9974	·9973	·9971	·9970	·9969	·9968	·9967	·9966	·9964	·9963	0	0	1	1
5	·9962	·9961	·9959	·9958	·9957	·9955	·9954	·9953	·9951	·9950	·9948	·9947	0	1	1	1
6	·9945	·9944	·9942	·9941	·9939	·9937	·9936	·9934	·9932	·9931	·9929	·9927	0	1	1	1
7	·9925	·9924	·9922	·9920	·9918	·9916	·9914	·9913	·9911	·9909	·9907	·9905	0	1	1	2
8	·9903	·9901	·9899	·9897	·9894	·9892	·9890	·9888	·9886	·9884	·9881	·9879	0	1	1	2
9	·9877	·9875	·9872	·9870	·9868	·9865	·9863	·9860	·9858	·9856	·9853	·9851	0	1	1	2
10	·9848	·9846	·9843	·9840	·9838	·9835	·9833	·9830	·9827	·9825	·9822	·9819	1	1	2	2
11	·9816	·9813	·9811	·9808	·9805	·9802	·9799	·9796	·9793	·9790	·9787	·9784	1	1	2	2
12	·9781	·9778	·9775	·9772	·9769	·9766	·9763	·9760	·9757	·9753	·9750	·9747	1	1	2	3
13	·9744	·9740	·9737	·9734	·9730	·9727	·9724	·9720	·9717	·9713	·9710	·9706	1	1	2	3
14	·9703	·9699	·9696	·9692	·9689	·9685	·9681	·9678	·9674	·9670	·9667	·9663	1	1	2	3
15	·9659	·9655	·9652	·9648	·9644	·9640	·9636	·9632	·9628	·9625	·9621	·9617	1	2	2	3
16	·9613	·9609	·9605	·9600	·9596	·9592	·9588	·9584	·9580	·9576	·9572	·9567	1	2	2	3
17	·9563	·9559	·9555	·9550	·9546	·9542	·9537	·9533	·9528	·9524	·9520	·9515	1	2	3	4
18	·9511	·9506	·9502	·9497	·9492	·9488	·9483	·9479	·9474	·9469	·9465	·9460	1	2	3	4
19	·9455	·9450	·9446	·9441	·9436	·9431	·9426	·9422	·9417	·9412	·9407	·9402	1	2	3	4
20	·9397	·9392	·9387	·9382	·9377	·9372	·9367	·9362	·9356	·9351	·9346	·9341	1	2	3	4
21	·9336	·9331	·9325	·9320	·9315	·9309	·9304	·9299	·9293	·9288	·9283	·9277	1	2	3	4
22	·9272	·9266	·9261	·9255	·9250	·9244	·9239	·9233	·9228	·9222	·9216	·9211	1	2	3	4
23	·9205	·9199	·9194	·9188	·9182	·9176	·9171	·9165	·9159	·9153	·9147	·9141	1	2	3	5
24	·9135	·9130	·9124	·9118	·9112	·9106	·9100	·9094	·9088	·9081	·9075	·9069	1	2	4	5
25	·9063	·9057	·9051	·9045	·9038	·9032	·9026	·9020	·9013	·9007	·9001	·8994	1	3	4	5
26	·8988	·8982	·8975	·8969	·8962	·8956	·8949	·8943	·8936	·8930	·8923	·8917	1	3	4	5
27	·8910	·8903	·8897	·8890	·8884	·8877	·8870	·8863	·8857	·8850	·8843	·8836	1	3	4	5
28	·8829	·8823	·8816	·8809	·8802	·8795	·8788	·8781	·8774	·8767	·8760	·8753	1	3	4	6
29	·8746	·8739	·8732	·8725	·8718	·8711	·8704	·8696	·8689	·8682	·8675	·8668	1	3	4	6
30	·8660	·8653	·8646	·8638	·8631	·8624	·8616	·8609	·8601	·8594	·8587	·8579	1	3	4	6
31	·8572	·8564	·8557	·8549	·8542	·8534	·8526	·8519	·8511	·8504	·8496	·8488	2	3	5	6
32	·8480	·8473	·8465	·8457	·8450	·8442	·8434	·8426	·8418	·8410	·8403	·8395	2	3	5	6
33	·8387	·8379	·8371	·8363	·8355	·8347	·8339	·8331	·8323	·8315	·8307	·8299	2	3	5	6
34	·8290	·8282	·8274	·8266	·8258	·8249	·8241	·8233	·8225	·8216	·8208	·8200	2	3	5	7
35	·8192	·8183	·8175	·8166	·8158	·8150	·8141	·8133	·8124	·8116	·8107	·8099	2	3	5	7
36	·8090	·8082	·8073	·8064	·8056	·8047	·8039	·8030	·8021	·8013	·8004	·7995	2	3	5	7
37	·7986	·7978	·7969	·7960	·7951	·7942	·7934	·7925	·7916	·7907	·7898	·7889	2	4	5	7
38	·7880	·7871	·7862	·7853	·7844	·7835	·7826	·7817	·7808	·7799	·7790	·7781	2	4	5	7
39	·7771	·7762	·7753	·7744	·7735	·7725	·7716	·7707	·7698	·7688	·7679	·7670	2	4	6	7
40	·7660	·7651	·7642	·7632	·7623	·7613	·7604	·7595	·7585	·7576	·7566	·7557	2	4	6	8
41	·7547	·7538	·7528	·7518	·7509	·7499	·7490	·7480	·7470	·7461	·7451	·7441	2	4	6	8
42	·7431	·7422	·7412	·7402	·7392	·7383	·7373	·7363	·7353	·7343	·7333	·7323	2	4	6	8
43	·7314	·7304	·7294	·7284	·7274	·7264	·7254	·7244	·7234	·7224	·7214	·7203	2	4	6	8
44	·7193	·7183	·7173	·7163	·7153	·7143	·7133	·7122	·7112	·7102	·7092	·7081	2	4	6	8

Natural Cosines

													Mean differences to be subtracted			
Deg	0′	5′	10′	15′	20′	25′	30′	35′	40′	45′	50′	55′	1′	2′	3′	4′
45	·7071	·7061	·7050	·7040	·7030	·7019	·7009	·6999	·6988	·6978	·6967	·6957	2	4	6	8
46	·6947	·6936	·6926	·6915	·6905	·6894	·6884	·6873	·6862	·6852	·6841	·6831	2	4	6	8
47	·6820	·6809	·6799	·6788	·6777	·6767	·6756	·6745	·6734	·6724	·6713	·6702	2	4	6	9
48	·6691	·6680	·6670	·6659	·6648	·6637	·6626	·6615	·6604	·6593	·6583	·6572	2	4	7	9
49	·6561	·6550	·6539	·6528	·6517	·6506	·6494	·6483	·6472	·6461	·6450	·6439	2	4	7	9
50	·6428	·6417	·6406	·6394	·6383	·6372	·6361	·6350	·6338	·6327	·6316	·6305	2	4	7	9
51	·6293	·6282	·6271	·6259	·6248	·6237	·6225	·6214	·6202	·6191	·6180	·6168	2	5	7	9
52	·6157	·6145	·6134	·6122	·6111	·6099	·6088	·6076	·6065	·6053	·6041	·6030	2	5	7	9
53	·6018	·6007	·5995	·5983	·5972	·5960	·5948	·5937	·5925	·5913	·5901	·5890	2	5	7	9
54	·5878	·5866	·5854	·5842	·5831	·5819	·5807	·5795	·5783	·5771	·5760	·5748	2	5	7	9
55	·5736	·5724	·5712	·5700	·5688	·5676	·5664	·5652	·5640	·5628	·5616	·5604	2	5	7	10
56	·5592	·5580	·5568	·5556	·5544	·5531	·5519	·5507	·5495	·5483	·5471	·5459	2	5	7	10
57	·5446	·5434	·5422	·5410	·5398	·5385	·5373	·5361	·5348	·5336	·5324	·5312	2	5	7	10
58	·5299	·5287	·5275	·5262	·5250	·5237	·5225	·5213	·5200	·5188	·5175	·5163	2	5	7	10
59	·5150	·5138	·5125	·5113	·5100	·5088	·5075	·5063	·5050	·5038	·5025	·5013	3	5	8	10
60	·5000	·4987	·4975	·4962	·4950	·4937	·4924	·4912	·4899	·4886	·4874	·4861	3	5	8	10
61	·4848	·4835	·4823	·4810	·4797	·4784	·4772	·4759	·4746	·4733	·4720	·4708	3	5	8	10
62	·4695	·4682	·4669	·4656	·4643	·4630	·4617	·4605	·4592	·4579	·4566	·4553	3	5	8	10
63	·4540	·4527	·4514	·4501	·4488	·4475	·4462	·4449	·4436	·4423	·4410	·4397	3	5	8	10
64	·4384	·4371	·4358	·4344	·4331	·4318	·4305	·4292	·4279	·4266	·4253	·4239	3	5	8	11
65	·4226	·4213	·4200	·4187	·4173	·4160	·4147	·4134	·4120	·4107	·4094	·4081	3	5	8	11
66	·4067	·4054	·4041	·4027	·4014	·4001	·3987	·3974	·3961	·3947	·3934	·3921	3	5	8	11
67	·3907	·3894	·3881	·3867	·3854	·3840	·3827	·3813	·3800	·3786	·3773	·3760	3	5	8	11
68	·3746	·3733	·3719	·3706	·3692	·3679	·3665	·3651	·3638	·3624	·3611	·3597	3	5	8	11
69	·3584	·3570	·3557	·3543	·3529	·3516	·3502	·3488	·3475	·3461	·3448	·3434	3	5	8	11
70	·3420	·3407	·3393	·3379	·3365	·3352	·3338	·3324	·3311	·3297	·3283	·3269	3	5	8	11
71	·3256	·3242	·3228	·3214	·3201	·3187	·3173	·3159	·3145	·3132	·3118	·3104	3	6	8	11
72	·3090	·3076	·3062	·3049	·3035	·3021	·3007	·2993	·2979	·2965	·2952	·2938	3	6	8	11
73	·2924	·2910	·2896	·2882	·2868	·2854	·2840	·2826	·2812	·2798	·2784	·2770	3	6	8	11
74	·2756	·2742	·2728	·2714	·2700	·2686	·2672	·2658	·2644	·2630	·2616	·2602	3	6	8	11
75	·2588	·2574	·2560	·2546	·2532	·2518	·2504	·2490	·2476	·2462	·2447	·2433	3	6	8	11
76	·2419	·2405	·2391	·2377	·2363	·2349	·2334	·2320	·2306	·2292	·2278	·2264	3	6	8	11
77	·2250	·2235	·2221	·2207	·2193	·2179	·2164	·2150	·2136	·2122	·2108	·2093	3	6	9	11
78	·2079	·2065	·2051	·2036	·2022	·2008	·1994	·1979	·1965	·1951	·1937	·1922	3	6	9	11
79	·1908	·1894	·1880	·1865	·1851	·1837	·1822	·1808	·1794	·1779	·1765	·1751	3	6	9	11
80	·1736	·1722	·1708	·1693	·1679	·1665	·1650	·1636	·1622	·1607	·1593	·1579	3	6	9	11
81	·1564	·1550	·1536	·1521	·1507	·1492	·1478	·1464	·1449	·1435	·1421	·1406	3	6	9	12
82	·1392	·1377	·1363	·1349	·1334	·1320	·1305	·1291	·1276	·1262	·1248	·1233	3	6	9	12
83	·1219	·1204	·1190	·1175	·1161	·1146	·1132	·1118	·1103	·1089	·1074	·1060	3	6	9	12
84	·1045	·1031	·1016	·1002	·0987	·0973	·0958	·0944	·0930	·0915	·0901	·0886	3	6	9	12
85	·0872	·0857	·0843	·0828	·0814	·0799	·0785	·0770	·0756	·0741	·0727	·0712	3	6	9	12
86	·0698	·0683	·0669	·0654	·0640	·0625	·0610	·0596	·0581	·0567	·0552	·0538	3	6	9	12
87	·0523	·0509	·0494	·0480	·0465	·0451	·0436	·0422	·0407	·0393	·0378	·0364	3	6	9	12
88	·0349	·0334	·0320	·0305	·0291	·0276	·0262	·0247	·0233	·0218	·0204	·0189	3	6	9	12
89	·0175	·0160	·0145	·0131	·0116	·0102	·0087	·0073	·0058	·0044	·0029	·0015	3	6	9	12

Logarithms of Cosines

Deg	0′	5′	10′	15′	20′	25′	30′	35′	40′	45′	50′	55′	Mean differences to be subtracted			
													1′	2′	3′	4′
0	0·0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	*9999	0	0	0	0
1	$\bar{1}$·9999	9999	9999	9999	9999	9999	9999	9998	9998	9998	9998	9998	0	0	0	0
2	$\bar{1}$·9997	9997	9997	9997	9996	9996	9996	9996	9995	9995	9995	9994	0	0	0	0
3	$\bar{1}$·9994	9994	9993	9993	9993	9992	9992	9992	9991	9991	9990	9990	0	0	0	0
4	$\bar{1}$·9989	9989	9989	9988	9988	9987	9987	9986	9986	9985	9985	9984	0	0	0	0
5	$\bar{1}$·9983	9983	9982	9982	9981	9981	9980	9979	9979	9978	9977	9977	0	0	0	0
6	$\bar{1}$·9976	9975	9975	9974	9973	9973	9972	9971	9971	9970	9969	9968	0	0	0	1
7	$\bar{1}$·9968	9967	9966	9965	9964	9964	9963	9962	9961	9960	9959	9958	0	0	1	1
8	$\bar{1}$·9958	9957	9956	9955	9954	9953	9952	9951	9950	9949	9948	9947	0	0	1	1
9	$\bar{1}$·9946	9945	9944	9943	9942	9941	9940	9939	9938	9937	9936	9935	0	0	1	1
10	$\bar{1}$·9934	9932	9931	9930	9929	9928	9927	9925	9924	9923	9922	9921	0	0	1	1
11	$\bar{1}$·9919	9918	9917	9916	9914	9913	9912	9911	9909	9908	9907	9905	0	1	1	1
12	$\bar{1}$·9904	9903	9901	9900	9899	9897	9896	9894	9893	9892	9890	9889	0	1	1	1
13	$\bar{1}$·9887	9886	9884	9883	9881	9880	9878	9877	9875	9874	9872	9871	0	1	1	1
14	$\bar{1}$·9869	9867	9866	9864	9863	9861	9859	9858	9856	9854	9853	9851	0	1	1	1
15	$\bar{1}$·9849	9848	9846	9844	9843	9841	9839	9837	9836	9834	9832	9830	0	1	1	1
16	$\bar{1}$·9828	9827	9825	9823	9821	9819	9817	9815	9814	9812	9810	9808	0	1	1	2
17	$\bar{1}$·9806	9804	9802	9800	9798	9796	9794	9792	9790	9788	9786	9784	0	1	1	2
18	$\bar{1}$·9782	9780	9778	9776	9774	9772	9770	9767	9765	9763	9761	9759	0	1	1	2
19	$\bar{1}$·9757	9755	9752	9750	9748	9746	9743	9741	9739	9737	9734	9732	0	1	1	2
20	$\bar{1}$·9730	9728	9725	9723	9721	9718	9716	9714	9711	9709	9706	9704	0	1	1	2
21	$\bar{1}$·9702	9699	9697	9694	9692	9689	9687	9684	9682	9679	9677	9674	0	1	1	2
22	$\bar{1}$·9672	9669	9667	9664	9661	9659	9656	9654	9651	9648	9646	9643	1	1	2	2
23	$\bar{1}$·9640	9638	9635	9632	9629	9627	9624	9621	9618	9616	9613	9610	1	1	2	2
24	$\bar{1}$·9607	9604	9602	9599	9596	9593	9590	9587	9584	9582	9579	9576	1	1	2	2
25	$\bar{1}$·9573	9570	9567	9564	9561	9558	9555	9552	9549	9546	9543	9540	1	1	2	2
26	$\bar{1}$·9537	9534	9530	9527	9524	9521	9518	9515	9512	9508	9505	9502	1	1	2	3
27	$\bar{1}$·9499	9496	9492	9489	9486	9483	9479	9476	9473	9469	9466	9463	1	1	2	3
28	$\bar{1}$·9459	9456	9453	9449	9446	9442	9439	9436	9432	9429	9425	9422	1	1	2	3
29	$\bar{1}$·9418	9415	9411	9408	9404	9401	9397	9393	9390	9386	9383	9379	1	1	2	3
30	$\bar{1}$·9375	9372	9368	9364	9361	9357	9353	9349	9346	9342	9338	9334	1	1	2	3
31	$\bar{1}$·9331	9327	9323	9319	9315	9312	9308	9304	9300	9296	9292	9288	1	2	2	3
32	$\bar{1}$·9284	9280	9276	9272	9268	9264	9260	9256	9252	9248	9244	9240	1	2	2	3
33	$\bar{1}$·9236	9232	9228	9224	9219	9215	9211	9207	9203	9198	9194	9190	1	2	3	3
34	$\bar{1}$·9186	9181	9177	9173	9169	9164	9160	9156	9151	9147	9142	9138	1	2	3	3
35	$\bar{1}$·9134	9129	9125	9120	9116	9111	9107	9102	9098	9093	9089	9084	1	2	3	4
36	$\bar{1}$·9080	9075	9070	9066	9061	9056	9052	9047	9042	9038	9033	9028	1	2	3	4
37	$\bar{1}$·9023	9019	9014	9009	9004	9000	8995	8990	8985	8980	8975	8970	1	2	3	4
38	$\bar{1}$·8965	8960	8955	8950	8945	8940	8935	8930	8925	8920	8915	8910	1	2	3	4
39	$\bar{1}$·8905	8900	8895	8890	8884	8879	8874	8869	8864	8858	8853	8848	1	2	3	4
40	$\bar{1}$·8843	8837	8832	8827	8821	8816	8810	8805	8800	8794	8789	8783	1	2	3	4
41	$\bar{1}$·8778	8772	8767	8761	8756	8750	8745	8739	8733	8728	8722	8716	1	2	3	4
42	$\bar{1}$·8711	8705	8699	8694	8688	8682	8676	8671	8665	8659	8653	8647	1	2	3	4
43	$\bar{1}$·8641	8635	8629	8624	8618	8612	8606	8600	8594	8588	8582	8575	1	2	4	5
44	$\bar{1}$·8569	8563	8557	8551	8545	8539	8532	8526	8520	8514	8507	8501	1	2	4	5

* Indicates that the characteristic is decreased by one.

Logarithms of Cosines

													Mean differences to be subtracted			
Deg	0′	5′	10′	15′	20′	25′	30′	35′	40′	45′	50′	55′	1′	2′	3′	4′
45	$\bar{1}$·8495	8489	8482	8476	8469	8463	8457	8450	8444	8437	8431	8424	1	3	4	5
46	$\bar{1}$·8418	8411	8405	8398	8391	8385	8378	8371	8365	8358	8351	8345	1	3	4	5
47	$\bar{1}$·8338	8331	8324	8317	8311	8304	8297	8290	8283	8276	8269	8262	1	3	4	6
48	$\bar{1}$·8255	8248	8241	8234	8227	8220	8213	8205	8198	8191	8184	8177	1	3	4	6
49	$\bar{1}$·8169	8162	8155	8148	8140	8133	8125	8118	8111	8103	8096	8088	1	3	4	6
50	$\bar{1}$·8081	8073	8066	8058	8050	8043	8035	8027	8020	8012	8004	7997	2	3	5	6
51	$\bar{1}$·7989	7981	7973	7965	7957	7949	7941	7934	7926	7918	7910	7901	2	3	5	6
52	$\bar{1}$·7893	7885	7877	7869	7861	7853	7844	7836	7828	7820	7811	7803	2	3	5	7
53	$\bar{1}$·7795	7786	7778	7769	7761	7752	7744	7735	7727	7718	7710	7701	2	3	5	7
54	$\bar{1}$·7692	7683	7675	7666	7657	7648	7640	7631	7622	7613	7604	7595	2	4	5	7
55	$\bar{1}$·7586	7577	7568	7559	7550	7540	7531	7522	7513	7504	7494	7485	2	4	6	7
56	$\bar{1}$·7476	7466	7457	7447	7438	7428	7419	7409	7400	7390	7380	7371	2	4	6	8
57	$\bar{1}$·7361	7351	7342	7332	7322	7312	7302	7292	7282	7272	7262	7252	2	4	6	8
58	$\bar{1}$·7242	7232	7222	7212	7201	7191	7181	7171	7160	7150	7139	7129	2	4	6	8
59	$\bar{1}$·7118	7108	7097	7087	7076	7065	7055	7044	7033	7022	7012	7001	2	4	6	9
60	$\bar{1}$·6990	6979	6968	6957	6946	6935	6923	6912	6901	6890	6878	6867	2	4	7	9
61	$\bar{1}$·6856	6844	6833	6821	6810	6798	6787	6775	6763	6752	6740	6728	2	5	7	9
62	$\bar{1}$·6716	6704	6692	6680	6668	6656	6644	6632	6620	6607	6595	6583	2	5	7	10
63	$\bar{1}$·6570	6558	6546	6533	6521	6508	6495	6483	6470	6457	6444	6431	3	5	8	10
64	$\bar{1}$·6418	6405	6392	6379	6366	6353	6340	6327	6313	6300	6286	6273	3	5	8	11
65	$\bar{1}$·6259	6246	6232	6219	6205	6191	6177	6163	6149	6135	6121	6107	3	6	8	11
66	$\bar{1}$·6093	6079	6065	6050	6036	6021	6007	5992	5978	5963	5948	5934	3	6	9	12
67	$\bar{1}$·5919	5904	5889	5874	5859	5844	5828	5813	5798	5782	5767	5751	3	6	9	12
68	$\bar{1}$·5736	5720	5704	5689	5673	5657	5641	5625	5609	5592	5576	5560	3	6	10	13
69	$\bar{1}$·5543	5527	5510	5494	5477	5460	5443	5426	5409	5392	5375	5358	3	7	10	14
70	$\bar{1}$·5341	5323	5306	5288	5270	5253	5235	5217	5199	5181	5163	5145	4	7	11	14
71	$\bar{1}$·5126	5108	5090	5071	5052	5034	5015	4996	4977	4958	4939	4919	4	8	11	15
72	$\bar{1}$·4900	4880	4861	4841	4821	4801	4781	4761	4741	4721	4700	4680	4	8	12	16
73	$\bar{1}$·4659	4639	4618	4597	4576	4555	4533	4512	4491	4469	4447	4425	4	9	13	17
74	$\bar{1}$·4403	4381	4359	4337	4314	4292	4269	4246	4223	4200	4177	4153	5	9	14	18
75	$\bar{1}$·4130	4106	4083	4059	4035	4010	3986	3962	3937	3912	3887	3862	5	10	15	20
76	$\bar{1}$·3837	3811	3786	3760	3734	3708	3682	3655	3629	3602	3575	3548	5	11	16	21
77	$\bar{1}$·3521	3493	3466	3438	3410	3382	3353	3325	3296	3267	3238	3208	6	11	17	23
78	$\bar{1}$·3179	3149	3119	3089	3058	3027	2997	2965	2934	2902	2870	2838	6	12	19	25
79	$\bar{1}$·2806	2773	2740	2707	2674	2640	2606	2572	2538	2503	2468	2432	7	14	20	27
80	$\bar{1}$·2397	2361	2324	2288	2251	2214	2176	2138	2100	2061	2022	1983	8	15	23	30
81	$\bar{1}$·1943	1903	1863	1822	1781	1739	1697	1655	1612	1568	1525	1480	8	17	25	34
82	$\bar{1}$·1436	1390	1345	1299	1252	1205	1157	1109	1060	1011	0961	0910	10	19	29	39
83	$\bar{1}$·0859	0807	0755	0702	0648	0594	0539	0483	0426	0369	0311	0252	11	22	33	45
84	$\bar{1}$·0192	0132	0070	0008	9945*	9881	9816	9750	9683	9614	9545	9475	13	26	40	53
85	$\bar{2}$·9403	9330	9256	9181	9104	9026	8946	8865	8783	8699	8613	8525	16	32	48	65
86	$\bar{2}$·8436	8345	8251	8156	8059	7959	7857	7752	7645	7535	7423	7307				
87	$\bar{2}$·7188	7066	6940	6810	6677	6539	6397	6250	6097	5940	5776	5605				
88	$\bar{2}$·5428	5243	5051	4849	4637	4414	4179	3931	3668	3388	3088	2766				
89	$\bar{2}$·2419	2041	1627	1169	0658	0078	9409*	8617	7648	6399	4638	1628				

* Indicates that the characteristic is decreased by one.

Natural Tangents

Deg	0′	5′	10′	15′	20′	25′	30′	35′	40′	45′	50′	55′	Mean differences			
													1′	2′	3′	4′
0	0·0000	·0015	·0029	·0044	·0058	·0073	·0087	·0102	·0116	·0131	·0145	·0160	3	6	9	12
1	·0175	·0189	·0204	·0218	·0233	·0247	·0262	·0276	·0291	·0306	·0320	·0335	3	6	9	12
2	·0349	·0364	·0378	·0393	·0407	·0422	·0437	·0451	·0466	·0480	·0495	·0509	3	6	9	12
3	·0524	·0539	·0553	·0568	·0582	·0597	·0612	·0626	·0641	·0655	·0670	·0685	3	6	9	12
4	·0699	·0714	·0729	·0743	·0758	·0772	·0787	·0802	·0816	·0831	·0846	·0860	3	6	9	12
5	·0875	·0890	·0904	·0919	·0934	·0948	·0963	·0978	·0992	·1007	·1022	·1036	3	6	9	12
6	·1051	·1066	·1080	·1095	·1110	·1125	·1139	·1154	·1169	·1184	·1198	·1213	3	6	9	12
7	·1228	·1243	·1257	·1272	·1287	·1302	·1317	·1331	·1346	·1361	·1376	·1391	3	6	9	12
8	·1405	·1420	·1435	·1450	·1465	·1480	·1495	·1509	·1524	·1539	·1554	·1569	3	6	9	12
9	·1584	·1599	·1614	·1629	·1644	·1658	·1673	·1688	·1703	·1718	·1733	·1748	3	6	9	12
10	·1763	·1778	·1793	·1808	·1823	·1838	·1853	·1868	·1883	·1899	·1914	·1929	3	6	9	12
11	·1944	·1959	·1974	·1989	·2004	·2019	·2035	·2050	·2065	·2080	·2095	·2110	3	6	9	12
12	·2126	·2141	·2156	·2171	·2186	·2202	·2217	·2232	·2247	·2263	·2278	·2293	3	6	9	12
13	·2309	·2324	·2339	·2355	·2370	·2385	·2401	·2416	·2432	·2447	·2462	·2478	3	6	9	12
14	·2493	·2509	·2524	·2540	·2555	·2571	·2586	·2602	·2617	·2633	·2648	·2664	3	6	9	12
15	·2679	·2695	·2711	·2726	·2742	·2758	·2773	·2789	·2805	·2820	·2836	·2852	3	6	9	13
16	·2867	·2883	·2899	·2915	·2931	·2946	·2962	·2978	·2994	·3010	·3026	·3041	3	6	9	13
17	·3057	·3073	·3089	·3105	·3121	·3137	·3153	·3169	·3185	·3201	·3217	·3233	3	6	10	13
18	·3249	·3265	·3281	·3298	·3314	·3330	·3346	·3362	·3378	·3395	·3411	·3427	3	6	10	13
19	·3443	·3460	·3476	·3492	·3508	·3525	·3541	·3558	·3574	·3590	·3607	·3623	3	7	10	13
20	·3640	·3656	·3673	·3689	·3706	·3722	·3739	·3755	·3772	·3789	·3805	·3822	3	7	10	13
21	·3839	·3855	·3872	·3889	·3906	·3922	·3939	·3956	·3973	·3990	·4006	·4023	3	7	10	13
22	·4040	·4057	·4074	·4091	·4108	·4125	·4142	·4159	·4176	·4193	·4210	·4228	3	7	10	14
23	·4245	·4262	·4279	·4296	·4314	·4331	·4348	·4365	·4383	·4400	·4417	·4435	3	7	10	14
24	·4452	·4470	·4487	·4505	·4522	·4540	·4557	·4575	·4592	·4610	·4628	·4645	4	7	11	14
25	·4663	·4681	·4699	·4716	·4734	·4752	·4770	·4788	·4806	·4823	·4841	·4859	4	7	11	14
26	·4877	·4895	·4913	·4931	·4950	·4968	·4986	·5004	·5022	·5040	·5059	·5077	4	7	11	15
27	·5095	·5114	·5132	·5150	·5169	·5187	·5206	·5224	·5243	·5261	·5280	·5298	4	7	11	15
28	·5317	·5336	·5354	·5373	·5392	·5411	·5430	·5448	·5467	·5486	·5505	·5524	4	8	11	15
29	·5543	·5562	·5581	·5600	·5619	·5639	·5658	·5677	·5696	·5715	·5735	·5754	4	8	12	15
30	·5774	·5793	·5812	·5832	·5851	·5871	·5890	·5910	·5930	·5949	·5969	·5989	4	8	12	16
31	·6009	·6028	·6048	·6068	·6088	·6108	·6128	·6148	·6168	·6188	·6208	·6228	4	8	12	16
32	·6249	·6269	·6289	·6310	·6330	·6350	·6371	·6391	·6412	·6432	·6453	·6473	4	8	12	16
33	·6494	·6515	·6536	·6556	·6577	·6598	·6619	·6640	·6661	·6682	·6703	·6724	4	8	13	17
34	·6745	·6766	·6787	·6809	·6830	·6851	·6873	·6894	·6916	·6937	·6959	·6980	4	9	13	17
35	·7002	·7024	·7046	·7067	·7089	·7111	·7133	·7155	·7177	·7199	·7221	·7243	4	9	13	18
36	·7265	·7288	·7310	·7332	·7355	·7377	·7400	·7422	·7445	·7467	·7490	·7513	5	9	14	18
37	·7536	·7558	·7581	·7604	·7627	·7650	·7673	·7696	·7720	·7743	·7766	·7789	5	9	14	19
38	·7813	·7836	·7860	·7883	·7907	·7931	·7954	·7978	·8002	·8026	·8050	·8074	5	10	14	19
39	·8098	·8122	·8146	·8170	·8195	·8219	·8243	·8268	·8292	·8317	·8342	·8366	5	10	15	20
40	·8391	·8416	·8441	·8466	·8491	·8516	·8541	·8566	·8591	·8617	·8642	·8667	5	10	15	20
41	·8693	·8718	·8744	·8770	·8796	·8821	·8847	·8873	·8899	·8925	·8952	·8978	5	10	16	21
42	·9004	·9030	·9057	·9083	·9110	·9137	·9163	·9190	·9217	·9244	·9271	·9298	5	11	16	21
43	·9325	·9352	·9380	·9407	·9435	·9462	·9490	·9517	·9545	·9573	·9601	·9629	6	11	17	22
44	·9657	·9685	·9713	·9742	·9770	·9798	·9827	·9856	·9884	·9913	·9942	·9971	6	11	17	23

Natural Tangents

													Mean differences			
Deg	0′	5′	10′	15′	20′	25′	30′	35′	40′	45′	50′	55′	1′	2′	3′	4′
45	1·0000	1·0029	1·0058	1·0088	1·0117	1·0147	1·0176	1·0206	1·0235	1·0265	1·0295	1·0325	6	12	18	24
46	1·0355	1·0385	1·0416	1·0446	1·0477	1·0507	1·0538	1·0569	1·0599	1·0630	1·0661	1·0692	6	12	18	25
47	1·0724	1·0755	1·0786	1·0818	1·0850	1·0881	1·0913	1·0945	1·0977	1·1009	1·1041	1·1074	6	13	19	26
48	1·1106	1·1139	1·1171	1·1204	1·1237	1·1270	1·1303	1·1336	1·1369	1·1403	1·1436	1·1470	7	13	20	27
49	1·1504	1·1538	1·1571	1·1606	1·1640	1·1674	1·1708	1·1743	1·1778	1·1812	1·1847	1·1882	7	14	21	28
50	1·1918	1·1953	1·1988	1·2024	1·2059	1·2095	1·2131	1·2167	1·2203	1·2239	1·2276	1·2312	7	14	22	29
51	1·2349	1·2386	1·2423	1·2460	1·2497	1·2534	1·2572	1·2609	1·2647	1·2685	1·2723	1·2761	8	15	23	30
52	1.2799	1·2838	1·2876	1·2915	1·2954	1·2993	1·3032	1·3072	1·3111	1·3151	1·3190	1·3230	8	16	24	31
53	1·3270	1·3311	1·3351	1·3392	1·3432	1·3473	1·3514	1·3555	1·3597	1·3638	1·3680	1·3722	8	16	25	33
54	1·3764	1·3806	1·3848	1·3891	1·3934	1·3976	1·4019	1·4063	1·4106	1·4150	1·4193	1·4237	9	17	26	35
55	1·4281	1·4326	1·4370	1·4415	1·4460	1·4505	1·4550	1·4596	1·4641	1·4687	1·4733	1·4779	9	18	27	36
56	1·4826	1·4872	1·4919	1·4966	1·5013	1·5061	1·5108	1·5156	1·5204	1·5253	1·5301	1·5350	10	19	29	38
57	1·5399	1·5448	1·5497	1·5547	1·5597	1·5647	1·5697	1·5747	1·5798	1·5849	1·5900	1·5952	10	20	30	40
58	1·6003	1·6055	1·6107	1·6160	1·6212	1·6265	1·6319	1·6372	1·6426	1·6479	1·6534	1·6588	11	21	32	43
59	1·6643	1·6698	1·6753	1·6808	1·6864	1·6920	1·6977	1·7033	1·7090	1·7147	1·7205	1·7262	11	23	34	45
60	1·7321	1·7379	1·7437	1·7496	1·7556	1·7615	1·7675	1·7735	1·7796	1·7856	1·7917	1·7979	12	24	36	48
61	1.8040	1·8103	1·8165	1·8228	1·8291	1.8354	1·8418	1·8482	1·8546	1·8611	1·8676	1·8741	13	26	38	51
62	1·8807	1·8873	1·8940	1·9007	1·9074	1·9142	1·9210	1·9278	1·9347	1·9416	1·9486	1·9556	14	27	41	55
63	1·9626	1·9697	1·9768	1·9840	1·9912	1·9984	2·0057	2·0130	2·0204	2·0278	2·0353	2·0428	15	29	44	59
64	2·0503	2·0579	2·0655	2·0732	2·0809	2·0887	2·0965	2·1044	2·1123	2·1203	2·1283	2·1364	16	31	47	63
65	2·1445	2·1527	2·1609	2·1692	2·1775	2·1859	2·1943	2·2028	2·2113	2·2199	2·2286	2·2373	17	34	51	68
66	2·2460	2·2549	2·2637	2·2727	2·2817	2·2907	2·2998	2·3090	2·3183	2·3276	2·3369	2·3464	18	37	55	73
67	2·3559	2·3654	2·3750	2·3847	2·3945	2·4043	2·4142	2·4242	2·4342	2·4443	2·4545	2·4648	20	40	60	80
68	2·4751	2·4855	2·4960	2·5065	2·5172	2·5279	2·5386	2·5495	2·5605	2·5715	2·5826	2·5938	22	43	65	87
69	2·6051	2·6165	2·6279	2·6395	2·6511	2·6628	2·6746	2·6865	2·6985	2·7106	2·7228	2·7351	24	48	71	95
70	2·7475	2·7600	2·7725	2·7852	2·7980	2·8109	2·8239	2·8370	2·8502	2·8636	2·8770	2·8905	26	52	79	105
71	2·9042	2·9180	2·9319	2·9459	2·9600	2·9743	2·9887	3·0032	3·0178	3·0326	3·0475	3·0625	29	58	87	116
72	3·0777	3·0930	3·1084	3·1240	3·1397	3·1556	3·1716	3·1878	3·2041	3·2205	3·2371	3·2539	32	64	97	129
73	3·2709	3·2879	3·3052	3·3226	3·3402	3·3580	3·3759	3·3941	3·4124	3·4308	3·4495	3·4684	36	72	109	145
74	3·4874	3·5067	3·5261	3·5457	3·5656	3·5856	3·6059	3·6264	3·6470	3·6680	3·6891	3·7105	41	82	123	164
75	3·7321	3·7539	3·7760	3·7983	3·8208	3·8436	3·8667	3·8900	3·9136	3·9375	3·9617	3·9861	46	93	140	186
76	4·0108	4·0358	4·0611	4·0867	4·1126	4·1388	4·1653	4·1922	4·2193	4·2468	4·2747	4·3029	53	107	161	215
77	4.3315	4·3604	4·3897	4·4194	4·4494	4·4799	4·5107	4·5420	4·5736	4·6057	4·6382	4·6712	53	107	161	215
78	4·7046	4·7385	4·7729	4·8077	4·8430	4·8788	4·9152	4·9520	4·9894	5·0273	5·0658	5·1049	53	107	161	215
79	5·1446	5·1848	5·2257	5·2672	5·3093	5·3521	5·3955	5·4397	5·4845	5·5301	5·5764	5·6234	53	107	161	215
80	5·6713	5·7199	5·7694	5·8197	5·8708	5·9228	5·9758	6·0296	6·0844	6·1402	6·1970	6·2549	53	107	161	215
81	6·3138	6·3737	6·4348	6·4971	6·5606	6·6252	6·6912	6·7584	6·8269	6·8969	6·9682	7·0410	53	107	161	215
82	7·1154	7·1912	7·2687	7·3479	7·4287	7·5113	7·5958	7·6821	7·7703	7·8606	7·9530	8·0476	53	107	161	215
83	8·1443	8·2434	8·3450	8·4490	8·5555	8·6648	8·7769	8·8918	9·0098	9·1309	9·2553	9·3831	53	107	161	215
84	9·5144	9·6493	9·7882	9·9310	10·078	10·229	10·385	10·546	10·712	10·883	11·059	11·242				
85	11·430	11·625	11·826	12·035	12·251	12·474	12·706	12·947	13·197	13·457	13·727	14·008				
86	14·301	14·606	14·924	15·257	15·605	15·969	16·350	16·750	17·169	17·611	18·075	18·564				
87	19·081	19·627	20·206	20·819	21·470	22·164	22·904	23·695	24·542	25·452	26·432	27·490				
88	28·636	29·882	31·242	32·730	34·368	36·178	38·188	40·436	42·964	45·829	49·104	52·882				
89	57·290	62·499	68·750	76·390	85·940	98·218	114·59	137·51	171·88	229·18	343·77	687·54				

Logarithms of Tangents

													Mean differences			
Deg	0′	5′	10′	15′	20′	25′	30′	35′	40′	45′	50′	55′	1′	2′	3′	4′
0	∞	$\bar{3}$·1627	4637	6398	7648	8617	9409	0078*	0658	1170	1627	2041				
1	$\bar{2}$·2419	2767	3089	3389	3669	3932	4181	4416	4638	4851	5053	5246				
2	$\bar{2}$·5431	5608	5779	5943	6101	6254	6401	6544	6682	6815	6945	7071				
3	$\bar{2}$·7194	7313	7429	7542	7652	7760	7865	7967	8067	8165	8261	8355				
4	$\bar{2}$·8446	8536	8624	8711	8795	8878	8960	9040	9118	9196	9272	9346	16	32	48	64
5	$\bar{2}$·9420	9492	9563	9633	9701	9769	9836	9901	9966	0030*	0093	0155	13	26	40	53
6	$\bar{1}$·0216	0277	0336	0395	0453	0510	0567	0622	0678	0732	0786	0839	11	22	34	45
7	$\bar{1}$·0891	0943	0995	1045	1096	1145	1194	1243	1291	1338	1385	1432	10	19	29	39
8	$\bar{1}$·1478	1524	1569	1613	1658	1702	1745	1788	1831	1873	1915	1956	9	17	26	34
9	$\bar{1}$·1997	2038	2078	2118	2158	2197	2236	2275	2313	2351	2389	2426	8	15	23	31
10	$\bar{1}$·2463	2500	2536	2573	2609	2644	2680	2715	2750	2784	2819	2853	7	14	21	28
11	$\bar{1}$·2887	2920	2953	2987	3020	3052	3085	3117	3149	3181	3212	3244	6	13	19	26
12	$\bar{1}$·3275	3306	3336	3367	3397	3428	3458	3487	3517	3546	3576	3605	6	12	18	24
13	$\bar{1}$·3634	3662	3691	3719	3748	3776	3804	3831	3859	3886	3914	3941	6	11	17	22
14	$\bar{1}$·3968	3995	4021	4048	4074	4100	4127	4153	4178	4204	4230	4255	5	10	16	21
15	$\bar{1}$·4281	4306	4331	4356	4381	4405	4430	4454	4479	4503	4527	4551	5	10	15	20
16	$\bar{1}$·4575	4599	4622	4646	4669	4693	4716	4739	4762	4785	4808	4831	5	9	14	19
17	$\bar{1}$·4853	4876	4898	4921	4943	4965	4987	5009	5031	5053	5075	5096	4	9	13	18
18	$\bar{1}$·5118	5139	5161	5182	5203	5224	5245	5266	5287	5308	5329	5349	4	8	13	17
19	$\bar{1}$·5370	5390	5411	5431	5451	5471	5491	5512	5531	5551	5571	5591	4	8	12	16
20	$\bar{1}$·5611	5630	5650	5669	5689	5708	5727	5747	5766	5785	5804	5823	4	8	12	15
21	$\bar{1}$·5842	5861	5879	5898	5917	5935	5954	5972	5991	6009	6028	6046	4	7	11	15
22	$\bar{1}$·6064	6082	6100	6118	6136	6154	6172	6190	6208	6226	6243	6261	4	7	11	14
23	$\bar{1}$·6279	6296	6314	6331	6348	6366	6383	6400	6417	6435	6452	6469	3	7	10	14
24	$\bar{1}$·6486	6503	6520	6537	6553	6570	6587	6604	6620	6637	6654	6670	3	7	10	13
25	$\bar{1}$·6687	6703	6720	6736	6752	6769	6785	6801	6817	6834	6850	6866	3	6	10	13
26	$\bar{1}$·6882	6898	6914	6930	6946	6962	6977	6993	7009	7025	7040	7056	3	6	9	13
27	$\bar{1}$·7072	7087	7103	7118	7134	7149	7165	7180	7196	7211	7226	7241	3	6	9	12
28	$\bar{1}$·7257	7272	7287	7302	7317	7333	7348	7363	7378	7393	7408	7423	3	6	9	12
29	$\bar{1}$·7438	7452	7467	7482	7497	7512	7526	7541	7556	7571	7585	7600	3	6	9	12
30	$\bar{1}$·7614	7629	7644	7658	7673	7687	7701	7716	7730	7745	7759	7773	3	6	9	12
31	$\bar{1}$·7788	7802	7816	7831	7845	7859	7873	7887	7902	7916	7930	7944	3	6	9	11
32	$\bar{1}$·7958	7972	7986	8000	8014	8028	8042	8056	8070	8084	8097	8111	3	6	8	11
33	$\bar{1}$·8125	8139	8153	8167	8180	8194	8208	8222	8235	8249	8263	8276	3	5	8	11
34	$\bar{1}$·8290	8303	8317	8331	8344	8358	8371	8385	8398	8412	8425	8439	3	5	8	11
35	$\bar{1}$·8452	8466	8479	8493	8506	8519	8533	8546	8559	8573	8586	8599	3	5	8	11
36	$\bar{1}$·8613	8626	8639	8652	8666	8679	8692	8705	8718	8732	8745	8758	3	5	8	11
37	$\bar{1}$·8771	8784	8797	8811	8824	8837	8850	8863	8876	8889	8902	8915	3	5	8	10
38	$\bar{1}$·8928	8941	8954	8967	8980	8993	9006	9019	9032	9045	9058	9071	3	5	8	10
39	$\bar{1}$·9084	9097	9110	9122	9135	9148	9161	9174	9187	9200	9212	9225	3	5	8	10
40	$\bar{1}$·9238	9251	9264	9277	9289	9302	9315	9328	9341	9353	9366	9379	3	5	8	10
41	$\bar{1}$·9392	9404	9417	9430	9443	9455	9468	9481	9494	9506	9519	9532	3	5	8	10
42	$\bar{1}$·9544	9557	9570	9582	9595	9608	9621	9633	9646	9659	9671	9684	3	5	8	10
43	$\bar{1}$·9697	9709	9722	9735	9747	9760	9772	9785	9798	9810	9823	9836	3	5	8	10
44	$\bar{1}$·9848	9861	9874	9886	9899	9912	9924	9937	9949	9962	9975	9987	3	5	8	10

* Indicates that the characteristic is increased by one.

Logarithms of Tangents

													Mean differences			
Deg	0′	5′	10′	15′	20′	25′	30′	35′	40′	45′	50′	55′	1′	2′	3′	4′
45	0·0000	0013	0025	0038	0051	0063	0076	0088	0101	0114	0126	0139	3	5	8	10
46	·0152	0164	0177	0190	0202	0215	0228	0240	0253	0265	0278	0291	3	5	8	10
47	·0303	0316	0329	0341	0354	0367	0379	0392	0405	0418	0430	0443	3	5	8	10
48	·0456	0468	0481	0494	0506	0519	0532	0545	0557	0570	0583	0596	3	5	8	10
49	·0608	0621	0634	0647	0659	0672	0685	0698	0711	0723	0736	0749	3	5	8	10
50	·0762	0775	0788	0800	0813	0826	0839	0852	0865	0878	0890	0903	3	5	8	10
51	·0916	0929	0942	0955	0968	0981	0994	1007	1020	1033	1046	1059	3	5	8	10
52	·1072	1085	1098	1111	1124	1137	1150	1163	1176	1189	1203	1216	3	5	8	10
53	·1229	1242	1255	1268	1282	1295	1308	1321	1334	1348	1361	1374	3	5	8	11
54	·1387	1401	1414	1427	1441	1454	1467	1481	1494	1507	1521	1534	3	5	8	11
55	·1548	1561	1575	1588	1602	1615	1629	1642	1656	1669	1583	1697	3	5	8	11
56	·1710	1724	1737	1751	1765	1778	1792	1806	1820	1833	1847	1861	3	5	8	11
57	·1875	1889	1903	1916	1930	1944	1958	1972	1986	2000	2014	2028	3	6	8	11
58	·2042	2056	2070	2084	2098	2113	2127	2141	2155	2169	2184	2198	3	6	9	11
59	·2212	2227	2241	2255	2270	2284	2299	2313	2327	2342	2356	2371	3	6	9	12
60	·2386	2400	2415	2429	2444	2459	2474	2488	2503	2518	2533	2548	3	6	9	12
61	·2562	2577	2592	2607	2622	2637	2652	2667	2683	2698	2713	2728	3	6	9	12
62	·2743	2759	2774	2789	2804	2820	2835	2851	2866	2882	2897	2913	3	6	9	13
63	·2928	2944	2960	2975	2991	3007	3023	3038	3054	3070	3086	3102	3	7	10	13
64	·3118	3134	3150	3166	3183	3199	3215	3231	3248	3264	3280	3297	3	7	10	13
65	·3313	3330	3346	3363	3380	3396	3413	3430	3447	3463	3480	3497	3	7	10	14
66	·3514	3531	3548	3565	3583	3600	3617	3634	3652	3669	3686	3704	4	7	11	14
67	·3721	3739	3757	3774	3792	3810	3828	3846	3864	3882	3900	3918	4	7	11	15
68	·3936	3954	3972	3991	4009	4028	4046	4065	4083	4102	4121	4139	4	8	12	15
69	·4158	4177	4196	4215	4234	4253	4273	4292	4311	4331	4350	4370	4	8	12	16
70	·4389	4409	4429	4449	4469	4488	4509	4529	4549	4569	4589	4610	4	8	13	17
71	·4630	4651	4671	4692	4713	4734	4755	4776	4797	4818	4839	4861	4	9	13	18
72	·4882	4904	4925	4947	4969	4991	5013	5035	5057	5079	5102	5124	5	9	14	19
73	·5147	5169	5192	5215	5238	5261	5284	5307	5331	5354	5378	5401	5	10	15	20
74	·5425	5449	5473	5497	5521	5546	5570	5595	5619	5644	5669	5694	5	10	16	21
75	·5719	5745	5770	5796	5822	5847	5873	5900	5926	5952	5979	6005	6	11	17	22
76	·6032	6059	6086	6114	6141	6169	6196	6224	6252	6281	6309	6338	6	12	18	24
77	·6366	6395	6424	6454	6483	6513	6542	6572	6603	6633	6664	6694	6	13	19	26
78	·6725	6756	6788	6819	6851	6883	6915	6948	6980	7013	7047	7080	7	14	21	28
79	·7113	7147	7181	7216	7250	7285	7320	7356	7391	7427	7464	7500	8	16	23	31
80	·7537	7574	7611	7649	7687	7725	7764	7803	7842	7882	7922	7962	9	17	26	35
81	·8003	8044	8085	8127	8169	8212	8255	8298	8342	8387	8431	8476	10	20	29	39
82	·8522	8568	8615	8662	8709	8757	8806	8855	8904	8955	9005	9057	11	23	34	45
83	·9109	9161	9214	9268	9322	9378	9433	9490	9547	9605	9664	9723	13	27	40	53
84	·9784	9845	9907	9970	**0034***	**0099**	**0164**	**0231**	**0299**	**0367**	**0437**	**0508**	16	32	49	65
85	1·0580	0654	0728	0804	0882	0960	1040	1122	1205	1289	1376	1464				
86	1·1554	1645	1739	1835	1933	2033	2135	2240	2348	2458	2571	2687				
87	1·2806	2929	3055	3185	3318	3456	3599	3746	3899	4057	4221	4392				
88	1·4569	4754	4947	5149	5362	5584	5819	6068	6331	6611	6911	7233				
89	1·7581	7959	8373	8830	9342	9922	**0591***	**1383**	**2352**	**3602**	**5363**	**8373**				

* Indicates that the characteristic is increased by one.

Natural Logarithms

	0	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9
1·0	0·0000	0100	0198	0296	0392	0488	0583	0677	0770	0862	10	19	29	38	48	57	67	76	86
1·1	0·0953	1044	1133	1222	1310	1398	1484	1570	1655	1740	9	17	26	35	44	52	61	70	78
1·2	0·1823	1906	1989	2070	2151	2231	2311	2390	2469	2546	8	16	24	32	40	48	56	64	72
1·3	0·2624	2700	2776	2852	2927	3001	3075	3148	3221	3293	7	15	22	30	37	44	52	59	67
1·4	0·3365	3436	3507	3577	3646	3716	3784	3853	3920	3988	7	14	21	28	35	41	48	55	62
1·5	0·4055	4121	4187	4253	4318	4383	4447	4511	4574	4637	6	13	19	26	32	39	45	52	58
1·6	0·4700	4762	4824	4886	4947	5008	5068	5128	5188	5247	6	12	18	24	30	36	42	48	55
1·7	0·5306	5365	5423	5481	5539	5596	5653	5710	5766	5822	6	11	17	23	29	34	40	46	51
1·8	0·5878	5933	5988	6043	6098	6152	6206	6259	6313	6366	5	11	16	22	27	32	38	43	49
1·9	0·6419	6471	6523	6575	6627	6678	6729	6780	6831	6881	5	10	15	20	26	31	36	41	46
2·0	0·6931	6981	7031	7080	7129	7178	7227	7275	7324	7372	5	10	15	20	24	29	34	39	44
2·1	0·7419	7467	7514	7561	7608	7655	7701	7747	7793	7839	5	9	14	19	23	28	33	37	42
2·2	0·7885	7930	7975	8020	8065	8109	8154	8198	8242	8286	4	9	13	18	22	27	31	36	40
2·3	0·8329	8372	8416	8459	8502	8544	8587	8629	8671	8713	4	9	13	17	21	26	30	34	38
2·4	0·8755	8796	8838	8879	8920	8961	9002	9042	9083	9123	4	8	12	16	20	24	29	33	37
2·5	0·9163	9203	9243	9282	9322	9361	9400	9439	9478	9517	4	8	12	16	20	24	27	31	35
2·6	0·9555	9594	9632	9670	9708	9746	9783	9821	9858	9895	4	8	11	15	19	23	26	30	34
2·7	0·9933	9969	$\bar{0}006$	$\bar{0}043$	$\bar{0}080$	$\bar{0}116$	$\bar{0}152$	$\bar{0}188$	$\bar{0}225$	$\bar{0}260$	4	7	11	15	18	22	25	29	33
2·8	1·0296	0332	0367	0403	0438	0473	0508	0543	0578	0613	4	7	11	14	18	21	25	28	32
2·9	1·0647	0682	0716	0750	0784	0818	0852	0886	0919	0953	3	7	10	14	17	20	24	27	31
3·0	1·0986	1019	1053	1086	1119	1151	1184	1217	1249	1282	3	7	10	13	16	20	23	26	30
3·1	1·1314	1346	1378	1410	1442	1474	1506	1537	1569	1600	3	6	10	13	16	19	22	25	29
3·2	1·1632	1663	1694	1725	1756	1787	1817	1848	1878	1909	3	6	9	12	15	18	22	25	28
3·3	1·1939	1969	2000	2030	2060	2090	2119	2149	2179	2208	3	6	9	12	15	18	21	24	27
3·4	1·2238	2267	2296	2326	2355	2384	2413	2442	2470	2499	3	6	9	12	15	17	20	23	26
3·5	1·2528	2556	2585	2613	2641	2669	2698	2726	2754	2782	3	6	8	11	14	17	20	23	25
3·6	1·2809	2837	2865	2892	2920	2947	2975	3002	3029	3056	3	5	8	11	14	16	19	22	25
3·7	1·3083	3110	3137	3164	3191	3218	3244	3271	3297	3324	3	5	8	11	13	16	19	21	24
3·8	1·3350	3376	3403	3429	3455	3481	3507	3533	3558	3584	3	5	8	10	13	16	18	21	23
3·9	1·3610	3635	3661	3686	3712	3737	3762	3788	3813	3838	3	5	8	10	13	15	18	20	23
4·0	1·3863	3888	3913	3938	3962	3987	4012	4036	4061	4085	2	5	7	10	12	15	17	20	22
4·1	1·4110	4134	4159	4183	4207	4231	4255	4279	4303	4327	2	5	7	10	12	14	17	19	22
4·2	1·4351	4375	4398	4422	4446	4469	4493	4516	4540	4563	2	5	7	9	12	14	16	19	21
4·3	1·4586	4609	4633	4656	4679	4702	4725	4748	4770	4793	2	5	7	9	12	14	16	18	21
4·4	1·4816	4839	4861	4884	4907	4929	4953	4974	4996	5019	2	5	7	9	11	14	16	18	20
4·5	1·5041	5063	5085	5107	5129	5151	5173	5195	5217	5239	2	4	7	9	11	13	15	18	20
4·6	1·5261	5282	5304	5326	5347	5369	5390	5412	5433	5454	2	4	6	9	11	13	15	17	19
4·7	1·5476	5497	5518	5539	5560	5581	5602	5623	5644	5665	2	4	6	8	11	13	15	17	19
4·8	1·5686	5707	5728	5748	5769	5790	5810	5831	5851	5872	2	4	6	8	10	12	14	16	19
4·9	1·5892	5913	5933	5953	5974	5994	6014	6034	6054	6074	2	4	6	8	10	12	14	16	18
5·0	1·6094	6114	6134	6154	6174	6194	6214	6233	6253	6273	2	4	6	8	10	12	14	16	18
5·1	1·6292	6312	6332	6351	6371	6390	6409	6429	6448	6467	2	4	6	8	10	12	14	16	18
5·2	1·6487	6506	6525	6544	6563	6582	6601	6620	6639	6658	2	4	6	8	10	11	13	15	17
5·3	1·6677	6696	6715	6734	6752	6771	6790	6808	6827	6845	2	4	6	7	9	11	13	15	17
5·4	1·6864	6882	6901	6919	6938	6956	6974	6993	7011	7029	2	4	5	7	9	11	13	15	17

Natural Logarithms

	0	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9
5·5	1·7047	7066	7084	7102	7120	7138	7156	7174	7192	7210	2	4	5	7	9	11	13	14	16
5·6	1·7228	7246	7263	7281	7299	7317	7334	7352	7370	7387	2	4	5	7	9	11	12	14	16
5·7	1·7405	7422	7440	7457	7475	7492	7509	7527	7544	7561	2	3	5	7	9	10	12	14	16
5·8	1·7579	7596	7613	7630	7647	7664	7681	7699	7716	7733	2	3	5	7	9	10	12	14	15
5·9	1·7750	7766	7783	7800	7817	7834	7851	7867	7884	7901	2	3	5	7	8	10	12	13	15
6·0	1·7918	7934	7951	7967	7984	8001	8017	8034	8050	8066	2	3	5	7	8	10	12	13	15
6·1	1·8083	8099	8116	8132	8148	8165	8181	8197	8213	8229	2	3	5	6	8	10	11	13	15
6·2	1·8245	8262	8278	8294	8310	8326	8342	8358	8374	8390	2	3	5	6	8	10	11	13	14
6·3	1·8405	8421	8437	8453	8469	8485	8500	8516	8532	8547	2	3	5	6	8	9	11	13	14
6·4	1·8563	8579	8594	8610	8625	8641	8656	8672	8687	8703	2	3	5	6	8	9	11	12	14
6·5	1·8718	8733	8749	8764	8779	8795	8810	8825	8840	8856	2	3	5	6	8	9	11	12	14
6·6	1·8871	8886	8901	8916	8931	8946	8961	8976	8991	9006	2	3	5	6	8	9	11	12	14
6·7	1·9021	9036	9051	9066	9081	9095	9110	9125	9140	9155	1	3	4	6	7	9	10	12	13
6·8	1·9169	9184	9199	9213	9228	9242	9257	9272	9286	9301	1	3	4	6	7	9	10	12	13
6·9	1·9315	9330	9344	9359	9373	9387	9402	9416	9430	9445	1	3	4	6	7	9	10	12	13
7·0	1·9459	9473	9488	9502	9516	9530	9544	9559	9573	9587	1	3	4	6	7	9	10	11	13
7·1	1·9601	9615	9629	9643	9657	9671	9685	9699	9713	9727	1	3	4	6	7	8	10	11	13
7·2	1·9741	9755	9769	9782	9796	9810	9824	9838	9851	9865	1	3	4	6	7	8	10	11	12
7·3	1·9879	9892	9906	9920	9933	9947	9961	9974	9988	$\bar{0}001$	1	3	4	5	7	8	10	11	12
7·4	2·0015	0028	0042	0055	0069	0082	0096	0109	0122	0136	1	3	4	5	7	8	9	11	12
7·5	2·0149	0162	0176	0189	0202	0215	0229	0242	0255	0268	1	3	4	5	7	8	9	11	12
7·6	2·0281	0295	0308	0321	0334	0347	0360	0373	0386	0399	1	3	4	5	7	8	9	10	12
7·7	2·0412	0425	0438	0451	0464	0477	0490	0503	0516	0528	1	3	4	5	6	8	9	10	12
7·8	2·0541	0554	0567	0580	0592	0605	0618	0631	0643	0656	1	3	4	5	6	8	9	10	11
7·9	2·0669	0681	0694	0707	0719	0732	0744	0757	0769	0782	1	3	4	5	6	8	9	10	11
8·0	2·0794	0807	0819	0832	0844	0857	0869	0882	0894	0906	1	3	4	5	6	7	9	10	11
8·1	2·0919	0931	0943	0956	0968	0980	0992	1005	1017	1029	1	2	4	5	6	7	9	10	11
8·2	2·1041	1054	1066	1078	1090	1102	1114	1126	1138	1150	1	2	4	5	6	7	9	10	11
8·3	2·1163	1175	1187	1199	1211	1223	1235	1247	1258	1270	1	2	4	5	6	7	8	10	11
8·4	2·1282	1294	1306	1318	1330	1342	1353	1365	1377	1389	1	2	4	5	6	7	8	10	11
8·5	2·1401	1412	1424	1436	1448	1459	1471	1483	1494	1506	1	2	4	5	6	7	8	9	11
8·6	2·1518	1529	1541	1552	1564	1576	1587	1599	1610	1622	1	2	3	5	6	7	8	9	10
8·7	2·1633	1645	1656	1668	1679	1691	1702	1713	1725	1736	1	2	3	5	6	7	8	9	10
8·8	2·1748	1759	1770	1782	1793	1804	1815	1827	1838	1849	1	2	3	5	6	7	8	9	10
8·9	2·1861	1872	1883	1894	1905	1917	1928	1939	1950	1961	1	2	3	4	6	7	8	9	10
9·0	2·1972	1983	1994	2006	2017	2028	2039	2050	2061	2072	1	2	3	4	6	7	8	9	10
9·1	2·2083	2094	2105	2116	2127	2138	2148	2159	2170	2181	1	2	3	4	5	7	8	9	10
9·2	2·2192	2203	2214	2225	2235	2246	2257	2268	2279	2289	1	2	3	4	5	6	8	9	10
9·3	2·2300	2311	2322	2332	2343	2354	2364	2375	2386	2396	1	2	3	4	5	6	7	9	10
9·4	2·2407	2418	2428	2439	2450	2460	2471	2481	2492	2502	1	2	3	4	5	6	7	8	10
9·5	2·2513	2523	2534	2544	2555	2565	2576	2586	2597	2607	1	2	3	4	5	6	7	8	9
9·6	2·2618	2628	2638	2649	2659	2670	2680	2690	2701	2711	1	2	3	4	5	6	7	8	9
9·7	2·2721	2732	2742	2752	2762	2773	2783	2793	2803	2814	1	2	3	4	5	6	7	8	9
9·8	2·2824	2834	2844	2854	2865	2875	2885	2895	2905	2915	1	2	3	4	5	6	7	8	9
9·9	2·2925	2935	2946	2956	2966	2976	2986	2996	3006	3016	1	2	3	4	5	6	7	8	9

Reciprocals

											Mean differences to be subtracted								
	0	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9
1·0	1·0000	9901	9804	9709	9615	9524	9434	9346	9259	9174	9	18	28	37	46	55	64	73	82
1·1	·9091	9009	8929	8850	8772	8696	8621	8547	8475	8403	8	15	23	31	38	46	54	61	69
1·2	·8333	8264	8197	8130	8065	8000	7937	7874	7813	7752	6	13	19	26	32	39	45	52	58
1·3	·7692	7634	7576	7519	7463	7407	7353	7299	7246	7194	6	11	17	22	28	33	39	44	50
1·4	·7143	7092	7042	6993	6944	6897	6849	6803	6757	6711	5	10	14	19	24	29	34	38	43
1·5	·6667	6623	6579	6536	6494	6452	6410	6369	6329	6289	4	8	13	17	21	25	29	34	38
1·6	·6250	6211	6173	6135	6098	6061	6024	5988	5952	5917	4	7	11	15	19	22	26	30	33
1·7	·5882	5848	5814	5780	5747	5714	5682	5650	5618	5587	3	7	10	13	16	20	23	26	30
1·8	·5556	5525	5495	5464	5435	5405	5376	5348	5319	5291	3	6	9	12	15	18	21	24	26
1·9	·5263	5236	5208	5181	5155	5128	5102	5076	5051	5025	3	5	8	11	13	16	19	21	24
2·0	·5000	4975	4950	4926	4902	4878	4854	4831	4808	4785	2	5	7	10	12	14	17	19	22
2·1	·4762	4739	4717	4695	4673	4651	4630	4608	4587	4566	2	4	7	9	11	13	15	17	20
2·2	·4545	4525	4505	4484	4464	4444	4425	4405	4386	4367	2	4	6	8	10	12	14	16	18
2·3	·4348	4329	4310	4292	4274	4255	4237	4219	4202	4184	2	4	5	7	9	11	13	15	16
2·4	·4167	4149	4132	4115	4098	4082	4065	4049	4032	4016	2	3	5	7	8	10	12	13	15
2·5	·4000	3984	3968	3953	3937	3922	3906	3891	3876	3861	2	3	5	6	8	9	11	12	14
2·6	·3846	3831	3817	3802	3788	3774	3759	3745	3731	3717	1	3	4	6	7	9	10	11	13
2·7	·3704	3690	3676	3663	3650	3636	3623	3610	3597	3584	1	3	4	5	7	8	9	11	12
2·8	·3571	3559	3546	3534	3521	3509	3497	3484	3472	3460	1	2	4	5	6	7	9	10	11
2·9	·3448	3436	3425	3413	3401	3390	3378	3367	3356	3344	1	2	3	5	6	7	8	9	10
3·0	·3333	3322	3311	3300	3289	3279	3268	3257	3247	3236	1	2	3	4	5	6	8	9	10
3·1	·3226	3215	3205	3195	3185	3175	3165	3155	3145	3135	1	2	3	4	5	6	7	8	9
3·2	·3125	3115	3106	3096	3086	3077	3067	3058	3049	3040	1	2	3	4	5	6	7	8	9
3·3	·3030	3021	3012	3003	2994	2985	2976	2967	2959	2950	1	2	3	4	4	5	6	7	8
3·4	·2941	2933	2924	2915	2907	2899	2890	2882	2874	2865	1	2	3	3	4	5	6	7	8
3·5	·2857	2849	2841	2833	2825	2817	2809	2801	2793	2786	1	2	2	3	4	5	6	6	7
3·6	·2778	2770	2762	2755	2747	2740	2732	2725	2717	2710	1	2	2	3	4	5	5	6	7
3·7	·2703	2695	2688	2681	2674	2667	2660	2653	2646	2639	1	1	2	3	4	4	5	6	6
3·8	·2632	2625	2618	2611	2604	2597	2591	2584	2577	2571	1	1	2	3	3	4	5	5	6
3·9	·2564	2558	2551	2545	2548	2532	2525	2519	2513	2506	1	1	2	3	3	4	5	5	6
4·0	·2500	2494	2488	2481	2475	2469	2463	2457	2451	2445	1	1	2	2	3	4	4	5	6
4·1	·2439	2433	2427	2421	2415	2410	2404	2398	2392	2387	1	1	2	2	3	3	4	5	5
4·2	·2381	2375	2370	2364	2358	2353	2347	2342	2336	2331	1	1	2	2	3	3	4	4	5
4·3	·2326	2320	2315	2309	2304	2299	2294	2288	2283	2278	1	1	2	2	3	3	4	4	5
4·4	·2273	2268	2262	2257	2252	2247	2242	2237	2232	2227	1	1	2	2	3	3	4	4	5
4·5	·2222	2217	2212	2208	2203	2198	2193	2188	2183	2179	0	1	1	2	2	3	3	4	4
4·6	·2174	2169	2165	2160	2155	2151	2146	2141	2137	2132	0	1	1	2	2	3	3	4	4
4·7	·2128	2123	2119	2114	2110	2105	2101	2096	2092	2088	0	1	1	2	2	3	3	4	4
4·8	·2083	2079	2075	2070	2066	2062	2058	2053	2049	2045	0	1	1	2	2	3	3	3	4
4·9	·2041	2037	2033	2028	2024	2020	2016	2012	2008	2004	0	1	1	2	2	2	3	3	4
5·0	·2000	1996	1992	1988	1984	1980	1976	1972	1969	1965	0	1	1	2	2	2	3	3	4
5·1	·1961	1957	1953	1949	1946	1942	1938	1934	1931	1927	0	1	1	2	2	2	3	3	3
5·2	·1923	1919	1916	1912	1908	1905	1901	1898	1894	1890	0	1	1	1	2	2	3	3	3
5·3	·1887	1883	1880	1876	1873	1869	1866	1862	1859	1855	0	1	1	1	2	2	2	3	3
5·4	·1852	1848	1845	1842	1838	1835	1832	1828	1825	1821	0	1	1	1	2	2	2	3	3

Reciprocals

											Mean differences to be subtracted								
	0	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9
5·5	·1818	1815	1812	1808	1805	1802	1799	1795	1792	1789	0	1	1	1	2	2	2	3	3
5·6	·1786	1783	1779	1776	1773	1770	1767	1764	1761	1757	0	1	1	1	2	2	2	3	3
5·7	·1754	1751	1748	1745	1742	1739	1736	1733	1730	1727	0	1	1	1	2	2	2	2	3
5·8	·1724	1721	1718	1715	1712	1709	1706	1704	1701	1698	0	1	1	1	1	2	2	2	3
5·9	·1695	1692	1689	1686	1684	1681	1678	1675	1672	1669	0	1	1	1	1	2	2	2	3
6·0	·1667	1664	1661	1658	1656	1653	1650	1647	1645	1642	0	1	1	1	1	2	2	2	2
6·1	·1639	1637	1634	1631	1629	1626	1623	1621	1618	1616	0	1	1	1	1	2	2	2	2
6·2	·1613	1610	1608	1605	1603	1600	1597	1595	1592	1590	0	1	1	1	1	2	2	2	2
6·3	·1587	1585	1582	1580	1577	1575	1572	1570	1567	1565	0	0	1	1	1	1	2	2	2
6·4	·1563	1560	1558	1555	1553	1550	1548	1546	1543	1541	0	0	1	1	1	1	2	2	2
6·5	·1538	1536	1534	1531	1529	1527	1524	1522	1520	1517	0	0	1	1	1	1	2	2	2
6·6	·1515	1513	1511	1508	1506	1504	1502	1499	1497	1495	0	0	1	1	1	1	2	2	2
6·7	·1493	1490	1488	1486	1484	1481	1479	1477	1475	1473	0	0	1	1	1	1	2	2	2
6·8	·1471	1468	1466	1464	1462	1460	1458	1456	1453	1451	0	0	1	1	1	1	1	2	2
6·9	·1449	1447	1445	1443	1441	1439	1437	1435	1433	1431	0	0	1	1	1	1	1	2	2
7·0	·1429	1427	1425	1422	1420	1418	1416	1414	1412	1410	0	0	1	1	1	1	1	2	2
7·1	·1408	1406	1404	1403	1401	1399	1397	1395	1393	1391	0	0	1	1	1	1	1	2	2
7·2	·1389	1387	1385	1383	1381	1379	1377	1376	1374	1372	0	0	1	1	1	1	1	2	2
7·3	·1370	1368	1366	1364	1362	1361	1359	1357	1355	1353	0	0	1	1	1	1	1	1	2
7·4	·1351	1350	1348	1346	1344	1342	1340	1339	1337	1335	0	0	1	1	1	1	1	1	2
7·5	·1333	1332	1330	1328	1326	1325	1323	1321	1319	1318	0	0	1	1	1	1	1	1	2
7·6	·1316	1314	1312	1311	1309	1307	1305	1304	1302	1300	0	0	1	1	1	1	1	1	2
7·7	·1299	1297	1295	1294	1292	1290	1289	1287	1285	1284	0	0	1	1	1	1	1	1	2
7·8	·1282	1280	1279	1277	1276	1274	1272	1271	1269	1267	0	0	0	1	1	1	1	1	1
7·9	·1266	1264	1263	1261	1259	1258	1256	1255	1253	1252	0	0	0	1	1	1	1	1	1
8·0	·1250	1248	1247	1245	1244	1242	1241	1239	1238	1236	0	0	0	1	1	1	1	1	1
8·1	·1235	1233	1232	1230	1229	1227	1225	1224	1222	1221	0	0	0	1	1	1	1	1	1
8·2	·1220	1218	1217	1215	1214	1212	1211	1209	1208	1206	0	0	0	1	1	1	1	1	1
8·3	·1205	1203	1202	1200	1199	1198	1196	1195	1193	1192	0	0	0	1	1	1	1	1	1
8·4	·1190	1189	1188	1186	1185	1183	1182	1181	1179	1178	0	0	0	1	1	1	1	1	1
8·5	·1176	1175	1174	1172	1171	1170	1168	1167	1166	1164	0	0	0	1	1	1	1	1	1
8·6	·1163	1161	1160	1159	1157	1156	1155	1153	1152	1151	0	0	0	1	1	1	1	1	1
8·7	·1149	1148	1147	1145	1144	1143	1142	1140	1139	1138	0	0	0	1	1	1	1	1	1
8·8	·1136	1135	1134	1133	1131	1130	1129	1127	1126	1125	0	0	0	1	1	1	1	1	1
8·9	·1124	1122	1121	1120	1119	1117	1116	1115	1114	1112	0	0	0	1	1	1	1	1	1
9·0	·1111	1110	1109	1107	1106	1105	1104	1103	1101	1100	0	0	0	0	1	1	1	1	1
9·1	·1099	1098	1096	1095	1094	1093	1092	1091	1089	1088	0	0	0	0	1	1	1	1	1
9·2	·1087	1086	1085	1083	1082	1081	1080	1079	1078	1076	0	0	0	0	1	1	1	1	1
9·3	·1075	1074	1073	1072	1071	1070	1068	1067	1066	1065	0	0	0	0	1	1	1	1	1
9·4	·1064	1063	1062	1060	1059	1058	1057	1056	1055	1054	0	0	0	0	1	1	1	1	1
9·5	·1053	1052	1050	1049	1048	1047	1046	1045	1044	1043	0	0	0	0	1	1	1	1	1
9·6	·1042	1041	1040	1038	1037	1036	1035	1034	1033	1032	0	0	0	0	1	1	1	1	1
9·7	·1031	1030	1029	1028	1027	1026	1025	1024	1022	1021	0	0	0	0	1	1	1	1	1
9·8	·1020	1019	1018	1017	1016	1015	1014	1013	1012	1011	0	0	0	0	1	1	1	1	1
9·9	·1010	1009	1008	1007	1006	1005	1004	1003	1002	1001	0	0	0	0	1	1	1	1	1

Degrees to Radian Measure

	0′	6′	12′	18′	24′	30′	36′	42′	48′	54′
0°	0·0000	0017	0035	0052	0070	0087	0105	0122	0140	0157
1	0·0175	0192	0209	0227	0244	0262	0279	0297	0314	0332
2	0·0349	0367	0384	0401	0419	0436	0454	0471	0489	0506
3	0·0524	0541	0559	0576	0593	0611	0628	0646	0663	0681
4	0·0698	0716	0733	0750	0768	0785	0803	0820	0838	0855
5	0·0873	0890	0908	0925	0942	0960	0977	0995	1012	1030
6	0·1047	1065	1082	1100	1117	1134	1152	1169	1187	1204
7	0·1222	1239	1257	1274	1292	1309	1326	1344	1361	1379
8	0·1396	1414	1431	1449	1466	1484	1501	1518	1536	1553
9	0·1571	1588	1606	1623	1641	1658	1676	1693	1710	1728
10°	0·1745	1763	1780	1798	1815	1833	1850	1868	1885	1902
11	0·1920	1937	1955	1972	1990	2007	2025	2042	2059	2077
12	0·2094	2112	2129	2147	2164	2182	2199	2217	2234	2251
13	0·2269	2286	2304	2321	2339	2356	2374	2391	2409	2426
14	0·2443	2461	2478	2496	2513	2531	2548	2566	2583	2601
15	0·2618	2635	2653	2670	2688	2705	2723	2740	2758	2775
16	0·2793	2810	2827	2845	2862	2880	2897	2915	2932	2950
17	0·2967	2985	3002	3019	3037	3054	3072	3089	3107	3124
18	0·3142	3159	3176	3194	3211	3229	3246	3264	3281	3299
19	0·3316	3334	3351	3368	3386	3403	3421	3438	3456	3473
20°	0·3491	3508	3526	3543	3560	3578	3595	3613	3630	3648
21	0·3665	3683	3700	3718	3735	3752	3770	3787	3805	3822
22	0·3840	3857	3875	3892	3910	3927	3944	3962	3979	3997
23	0·4014	4032	4049	4067	4084	4102	4119	4136	4154	4171
24	0·4189	4206	4224	4241	4259	4276	4294	4311	4328	4346
25	0·4363	4381	4398	4416	4433	4451	4468	4485	4503	4520
26	0·4538	4555	4573	4590	4608	4625	4643	4660	4677	4695
27	0·4712	4730	4747	4765	4782	4800	4817	4835	4852	4869
28	0·4887	4904	4922	4939	4957	4974	4992	5009	5027	5044
29	0·5061	5079	5096	5114	5131	5149	5166	5184	5201	5219
30°	0·5236	5253	5271	5288	5306	5323	5341	5358	5376	5393
31	0·5411	5428	5445	5463	5480	5498	5515	5533	5550	5568
32	0·5585	5603	5620	5637	5655	5672	5690	5707	5725	5742
33	0·5760	5777	5794	5812	5829	5847	5864	5882	5899	5917
34	0·5934	5952	5969	5986	6004	6021	6039	6056	6074	6091
35	0·6109	6126	6144	6161	6178	6196	6213	6231	6248	6266
36	0·6283	6301	6318	6336	6353	6370	6388	6405	6423	6440
37	0·6458	6475	6493	6510	6528	6545	6562	6580	6597	6615
38	0·6632	6650	6667	6685	6702	6720	6737	6754	6772	6789
39	0·6807	6824	6842	6859	6877	6894	6912	6929	6946	6964
40°	0·6981	6999	7016	7034	7051	7069	7086	7103	7121	7138
41	0·7156	7173	7191	7208	7226	7243	7261	7278	7295	7313
42	0·7330	7348	7365	7383	7400	7418	7435	7453	7470	7487
43	0·7505	7522	7540	7557	7575	7592	7610	7627	7645	7662
44	0·7679	7697	7714	7732	7749	7767	7784	7802	7819	7837

Difference

for	is
1′	3
2′	6
3′	9
4′	12
5′	15

Degrees to Radian Measure

	0′	6′	12′	18′	24′	30′	36′	42′	48′	54′
45	0·7854	7871	7889	7906	7924	7941	7959	7976	7994	8011
46	0·8029	8046	8063	8081	8098	8116	8133	8151	8168	8186
47	0·8203	8221	8238	8255	8273	8290	8308	8325	8343	8360
48	0·8378	8395	8412	8430	8447	8465	8482	8500	8517	8525
49	0·8552	8570	8587	8604	8622	8639	8657	8674	8692	8709
50	0·8727	8744	8762	8779	8796	8814	8831	8849	8866	8884
51	0·8901	8919	8936	8954	8971	8988	9006	9023	9041	9058
52	0·9076	9093	9111	9128	9146	9163	9180	9198	9215	9233
53	0·9250	9268	9285	9303	9320	9338	9355	9372	9390	9407
54	0·9425	9442	9460	9477	9495	9512	9529	9547	9564	9582
55	0·9599	9617	9634	9652	9669	9687	9704	9721	9739	9756
56	0·9774	9791	9809	9826	9844	9861	9879	9896	9913	9931
57	0·9948	9966	9983	1·0001	1·0018	1·0036	1·0053	1·0071	1·0088	1·0105
58	1·0123	1·0140	1·0158	1·0175	1·0193	1·0210	1·0228	1·0245	1·0263	1·0280
59	1·0297	1·0315	1·0332	1·0350	1·0367	1·0385	1·0402	1·0420	1·0437	1·0455
60	1·0472	1·0489	1·0507	1·0524	1·0542	1·0559	1·0577	1·0594	1·0612	1·0629
61	1·0647	1·0664	1·0681	1·0699	1·0716	1·0734	1·0751	1·0769	1·0786	1·0804
62	1·0821	1·0838	1·0856	1·0873	1·0891	1·0908	1·0926	1·0943	1·0961	1·0978
63	1·0996	1·1013	1·1030	1·1048	1·1065	1·1083	1·1100	1·1118	1·1135	1·1153
64	1·1170	1·1188	1·1205	1·1222	1·1240	1·1257	1·1275	1·1292	1·1310	1·1327
65	1·1345	1·1362	1·1380	1·1397	1·1414	1·1432	1·1449	1·1467	1·1484	1·1502
66	1·1519	1·1537	1·1554	1·1572	1·1589	1·1606	1·1624	1·1641	1·1659	1·1676
67	1·1694	1·1711	1·1729	1·1746	1·1764	1·1781	1·1798	1·1816	1·1833	1·1851
68	1·1868	1·1886	1·1903	1·1921	1·1938	1·1956	1·1973	1·1990	1·2008	1·2025
69	1·2043	1·2060	1·2078	1·2095	1·2113	1·2130	1·2147	1·2165	1·2182	1·2200
70	1·2217	1·2235	1·2252	1·2270	1·2287	1·2305	1·2322	1·2339	1·2357	1·2374
71	1·2392	1·2409	1·2427	1·2444	1·2462	1·2479	1·2497	1·2514	1·2531	1·2549
72	1·2566	1·2584	1·2601	1·2619	1·2636	1·2554	1·2671	1·2689	1·2706	1·2723
73	1·2741	1·2758	1·2776	1·2793	1·2811	1·2828	1·2846	1·2863	1·2881	1·2898
74	1·2915	1·2933	1·2950	1·2968	1·2985	1·3003	1·3020	1·3038	1·3055	1·3073
75	1·3090	1·3107	1·3125	1·3142	1·3160	1·3177	1·3195	1·3212	1·3230	1·3247
76	1·3265	1·3282	1·3299	1·3317	1·3334	1·3352	1·3369	1·3387	1·3404	1·3422
77	1·3439	1·3456	1·3474	1·3491	1·3509	1·3526	1·3544	1·3561	1·3579	1·3596
78	1·3614	1·3631	1·3648	1·3666	1·3683	1·3701	1·3718	1·3736	1·3753	1·3771
79	1·3788	1·3806	1·3823	1·3840	1·3858	1·3875	1·3893	1·3910	1·3928	1·3945
80	1·3963	1·3980	1·3998	1·4015	1·4032	1·4050	1·4067	1·4085	1·4102	1·4120
81	1·4137	1·4155	1·4172	1·4190	1·4207	1·4224	1·4242	1·4259	1·4277	1·4294
82	1·4312	1·4329	1·4347	1·4364	1·4382	1·4399	1·4416	1·4434	1·4451	1·4469
83	1·4486	1·4504	1·4521	1·4539	1·4556	1·4573	1·4591	1·4608	1·4626	1·4643
84	1·4661	1·4678	1·4696	1·4713	1·4731	1·4748	1·4765	1·4783	1·4800	1·4818
85	1·4835	1·4853	1·4870	1·4888	1·4905	1·4923	1·4940	1·4957	1·4975	1·4992
86	1·5010	1·5027	1·5045	1·5062	1·5080	1·5097	1·5115	1·5132	1·5149	1·5167
87	1·5184	1·5202	1·5219	1·5237	1·5254	1·5272	1·5289	1·5307	1·5324	1·5341
88	1·5359	1·5376	1·5394	1·5411	1·5429	1·5446	1·5464	1·5481	1·5499	1·5516
89	1·5533	1·5551	1·5568	1·5586	1·5603	1·5621	1·5638	1·5656	1·5673	1·5691

Difference

for	is
1′	3
2′	6
3′	9
4′	12
5′	15

Radians to Degrees

Rad	Deg	Deg	Min	Rad	Deg	Deg	Min	Rad	Deg	Deg	Min	Rad	Deg	Deg	Min
·01	·57	0	34	·46	26·36	26	21	·91	52·14	52	8	1·36	77·92	77	55
·02	1·15	1	9	·47	26·93	26	56	·92	52·71	52	43	1·37	78·50	78	30
·03	1·72	1	43	·48	27·50	27	30	·93	53·29	53	17	1·38	79·07	79	4
·04	2·29	2	18	·49	28·07	28	4	·94	53·86	53	51	1·39	79·64	79	38
·05	2·86	2	52	·50	28·65	28	39	·95	54·43	54	26	1·40	80·21	80	13
·06	3·44	3	26	·51	29·22	29	13	·96	55·00	55	0	1·41	80·79	80	47
·07	4·01	4	1	·52	29·79	29	48	·97	55·58	55	35	1·42	81·36	81	22
·08	4·58	4	35	·53	30·37	30	22	·98	56·15	56	9	1·43	81·93	81	56
·09	5·16	5	9	·54	30·94	30	56	·99	56·72	56	43	1·44	82·51	82	30
·10	5·73	5	44	·55	31·51	31	31	1·00	57·30	57	18	1·45	83·08	83	5
·11	6·30	6	18	·56	32·09	32	5	1·01	57·87	57	52	1·46	83·65	83	39
·12	6·88	6	53	·57	32·66	32	40	1·02	58·44	58	27	1·47	84·22	84	13
·13	7·45	7	27	·58	33·23	33	14	1·03	59·01	59	1	1·48	84·80	84	48
·14	8·02	8	1	·59	33·80	33	48	1·04	59·59	59	35	1·49	85·37	85	22
·15	8·59	8	36	·60	34·38	34	23	1·05	60·16	60	10	1·50	85·94	85	57
·16	9·17	9	10	·61	34·95	34	57	1·06	60·73	60	44	1·51	86·52	86	31
·17	9·74	9	44	·62	35·52	35	31	1·07	61·31	61	18	1·52	87·09	87	5
·18	10·31	10	19	·63	36·10	36	6	1·08	61·88	61	53	1·53	87·66	87	40
·19	10·89	10	53	·64	36·67	36	40	1·09	62·45	62	27	1·54	88·24	88	14
·20	11·46	11	28	·65	37·24	37	15	1·10	63·03	63	2	1·55	88·81	88	49
·21	12·03	12	2	·66	37·82	37	49	1·11	63·60	63	36	1·56	89·38	89	23
·22	12·61	12	36	·67	38·39	38	23	1·12	64·17	64	10	1·57	89·95	89	57
·23	13·18	13	11	·68	38·96	38	58	1·13	64·74	64	45				
·24	13·75	13	45	·69	39·53	39	32	1·14	65·32	65	19				
·25	14·32	14	19	·70	40·11	40	6	1·15	65·89	65	53				
·26	14·90	14	54	·71	40·68	40	41	1·16	66·46	66	28				
·27	15·47	15	28	·72	41·25	41	15	1·17	67·04	67	2				
·28	16·04	16	3	·73	41·83	41	50	1·18	67·61	67	37				
·29	16·62	16	37	·74	42·40	42	24	1·19	68·18	68	11				
·30	17·19	17	11	·75	42·97	42	58	1·20	68·75	68	45				
·31	17·76	17	46	·76	43·54	43	33	1·21	69·33	69	20				
·32	18·33	18	20	·77	44·12	44	7	1·22	69·90	69	54				
·33	18·91	18	54	·78	44·69	44	41	1·23	70·47	70	28				
·34	19·48	19	29	·79	45·26	45	16	1·24	71·05	71	3				
·35	20·05	20	3	·80	45·84	45	50	1·25	71·62	71	37				
·36	20·63	20	38	·81	46·41	46	25	1·26	72·19	72	12				
·37	21·20	21	12	·82	46·98	46	59	1·27	72·77	72	46				
·38	21·77	21	46	·83	47·56	47	33	1·28	73·34	73	20				
·39	22·35	22	21	·84	48·13	48	8	1·29	73·91	73	55				
·40	22·92	22	55	·85	48·70	48	42	1·30	74·48	74	29				
·41	23·49	23	29	·86	49·27	49	16	1·31	75·06	75	3				
·42	24·06	24	4	·87	49·85	49	51	1·32	75·63	75	38				
·43	24·64	24	38	·88	50·42	50	25	1·33	76·20	76	12				
·44	25·21	25	13	·89	50·99	50	60	1·34	76·78	76	47				
·45	25·78	25	47	·90	51·57	51	34	1·35	77·35	77	21				

Exponential and Hyperbolic Functions

x	e^x	e^{-x}	cosh x	sinh x	tanh x	log cosh x	log sinh x
0·1	1·1052	0·9048	1·0050	0·1002	0·0997	0·0022	$\bar{1}$·0007
0·2	1·2214	0·8187	1·0201	0·2013	0·1974	0·0086	$\bar{1}$·3039
0·3	1·3499	0·7408	1·0453	0·3045	0·2913	0·0193	$\bar{1}$·8436
0·4	1·4918	0·6703	1·0811	0·4108	0·3799	0·0339	$\bar{1}$·6136
0·5	1·6487	0·6065	1·1276	0·5211	0·4621	0·0522	$\bar{1}$·7169
0·6	1·8221	0·5488	1·1855	0·6367	0·5370	0·0739	$\bar{1}$·8093
0·7	2·0138	0·4966	1·2552	0·7586	0·6044	0·0987	$\bar{1}$·8800
0·8	2·2255	0·4493	1·3374	0·8881	0·6640	0·1263	$\bar{1}$·9485
0·9	2·4596	0·4066	1·4331	1·0265	0·7163	0·1563	0·0114
1·0	2·7183	0·3679	1·5431	1·1752	0·7616	0·1884	0·0701
1·1	3·0042	0·3329	1·6685	1·3356	0·8005	0·2223	0·1257
1·2	3·3201	0·3012	1·8107	1·5095	0·8337	0·2578	0·1788
1·3	3·6693	0·2725	1·9709	1·6984	0·8617	0·2947	0·2300
1·4	4·0552	0·2466	2·1509	1·9043	0·8854	0·3326	0·2797
1·5	4·4817	0·2231	2·3524	2·1293	0·9051	0·3715	0·3282
1·6	4·9530	0·2019	2·5775	2·3756	0·9217	0·4112	0·3758
1·7	5·4739	0·1827	2·8283	2·6456	0·9354	0·4515	0·4225
1·8	6·0496	0·1653	3·1075	2·9422	0·9468	0·4924	0·4687
1·9	6·6859	0·1496	3·4177	3·2682	0·9562	0·5337	0·5143
2·0	7·3891	0·1353	3·7622	3·6269	0·9640	0·5754	0·5595
2·1	8·1662	0·1225	4·1443	4·0219	0·9705	0·6175	0·6044
2·2	9·0250	0·1108	4·5679	4·4571	0·9757	0·6597	0·6491
2·3	9·9742	0·1003	5·0372	4·9370	0·9801	0·7022	0·6935
2·4	11·023	0·0907	5·5569	5·4662	0·9837	0·7448	0·7377
2·5	12·183	0·0821	6·1323	6·0502	0·9866	0·7876	0·7818
2·6	13·464	0·0743	6·7690	6·6947	0·9890	0·8305	0·8257
2·7	14·880	0·0672	7·4735	7·4063	0·9910	0·8735	0·8696
2·8	16·445	0·0608	8·2527	8·1919	0·9926	0·9166	0·9134
2·9	18·174	0·0550	9·1146	9·0596	0·9940	0·9597	0·9571
3·0	20·086	0·0498	10·068	10·018	0·9951	1·0029	1·0008
3·1	22·198	0·0450	11·121	11·076	0·9959	1·0462	1·0444
3·2	24·533	0·0408	12·287	12·246	0·9967	1·0894	1·0880
3·3	27·113	0·0369	13·575	13·538	0·9973	1·1327	1·1316
3·4	29·964	0·0334	14·999	14·965	0·9978	1·1761	1·1751
3·5	33·115	0·0302	16·573	16·543	0·9982	1·2194	1·2186
3·6	36·598	0·0273	18·313	18·285	0·9985	1·2628	1·2621
3·7	40·447	0·0247	20·236	20·211	0·9988	1·3061	1·3056
3·8	44·701	0·0224	22·362	22·339	0·9990	1·3495	1·3491
3·9	49·402	0·0202	24·711	24·691	0·9992	1·3929	1·3925
4·0	54·598	0·0183	27·308	27·290	0·9993	1·4363	1·4360
4·1	60·340	0·0166	30·178	30·162	0·9995	1·4797	1·4795
4·2	66·686	0·0150	33·351	33·336	0·9996	1·5231	1·5229
4·3	73·700	0·0136	36·857	36·843	0·9996	1·5665	1·5664
4·4	81·451	0·0123	40·732	40·719	0·9997	1·6099	1·6098
4·5	90·017	0·0111	45·014	45·003	0·9997	1·6533	1·6532
4·6	99·484	0·0101	49·747	49·737	0·9998	1·6968	1·6967
4·7	109·95	0·0091	54·978	54·969	0·9998	1·7402	1·7401
4·8	121·51	0·0082	60·759	60·751	0·9999	1·7836	1·7836
4·9	134·29	0·0074	67·149	67·141	0·9999	1·8270	1·8270
5·0	148·41	0·0067	74·210	74·203	0·9999	1·8705	1·8704

Square Roots

	0	1	2	3	4	5	6	7	8	9	Mean Differences								
											1	2	3	4	5	6	7	8	9
1·0	1·000	1·005	1·010	1·015	1·020	1·025	1·030	1·034	1·039	1·044	0	1	1	2	2	3	3	4	4
1·1	1·049	1·054	1·058	1·063	1·068	1·072	1·077	1·082	1·086	1·091	0	1	1	2	2	3	3	4	4
1·2	1·095	1·100	1·105	1·109	1·114	1·118	1·123	1·127	1·131	1·136	0	1	1	2	2	3	3	4	4
1·3	1·140	1·145	1·149	1·153	1·158	1·162	1·166	1·171	1·175	1·179	0	1	1	2	2	3	3	3	4
1·4	1·183	1·187	1·192	1·196	1·200	1·204	1·208	1·212	1·217	1·221	0	1	1	2	2	2	3	3	4
1·5	1·225	1·229	1·233	1·237	1·241	1·245	1·249	1·253	1·257	1·261	0	1	1	2	2	2	3	3	4
1·6	1·265	1·269	1·273	1·277	1·281	1·285	1·288	1·292	1·296	1·300	0	1	1	2	2	2	3	3	3
1·7	1·304	1·308	1·312	1·315	1·319	1·323	1·327	1·330	1·334	1·338	0	1	1	2	2	2	3	3	3
1·8	1·342	1·345	1·349	1·353	1·357	1·360	1·364	1·368	1·371	1·375	0	1	1	1	2	2	3	3	3
1·9	1·378	1·382	1·386	1·389	1·393	1·396	1·400	1·404	1·407	1·411	0	1	1	1	2	2	3	3	3
2·0	1·414	1·418	1·421	1·425	1·428	1·432	1·435	1·439	1·442	1·446	0	1	1	1	2	2	2	3	3
2·1	1·449	1·453	1·456	1·460	1·463	1·466	1·470	1·473	1·477	1·480	0	1	1	1	2	2	2	3	3
2·2	1·483	1·487	1·490	1·493	1·497	1·500	1·503	1·507	1·510	1·513	0	1	1	1	2	2	2	3	3
2·3	1·517	1·520	1·523	1·526	1·530	1·533	1·536	1·539	1·543	1·546	0	1	1	1	2	2	2	3	3
2·4	1·549	1·552	1·556	1·559	1·562	1·565	1·568	1·572	1·575	1·578	0	1	1	1	2	2	2	3	3
2·5	1·581	1·584	1·587	1·591	1·594	1·597	1·600	1·603	1·606	1·609	0	1	1	1	2	2	2	3	3
2·6	1·612	1·616	1·619	1·622	1·625	1·628	1·631	1·634	1·637	1·640	0	1	1	1	2	2	2	2	3
2·7	1·643	1·646	1·649	1·652	1·655	1·658	1·661	1·664	1·667	1·670	0	1	1	1	2	2	2	2	3
2·8	1·673	1·676	1·679	1·682	1·685	1·688	1·691	1·694	1·697	1·700	0	1	1	1	1	2	2	2	3
2·9	1·703	1·706	1·709	1·712	1·715	1·718	1·720	1·723	1·726	1·729	0	1	1	1	1	2	2	2	3
3·0	1·732	1·735	1·738	1·741	1·744	1·746	1·749	1·752	1·755	1·758	0	1	1	1	1	2	2	2	3
3·1	1·761	1·764	1·766	1·769	1·772	1·775	1·778	1·780	1·783	1·786	0	1	1	1	1	2	2	2	3
3·2	1·789	1·792	1·794	1·797	1·800	1·803	1·806	1·808	1·811	1·814	0	1	1	1	1	2	2	2	2
3·3	1·817	1·819	1·822	1·825	1·828	1·830	1·833	1·836	1·839	1·841	0	1	1	1	1	2	2	2	2
3·4	1·844	1·847	1·849	1·852	1·855	1·857	1·860	1·863	1·866	1·868	0	1	1	1	1	2	2	2	2
3·5	1·871	1·874	1·876	1·879	1·882	1·884	1·887	1·889	1·892	1·895	0	1	1	1	1	2	2	2	2
3·6	1·897	1·900	1·903	1·905	1·908	1·911	1·913	1·916	1·918	1·921	0	1	1	1	1	2	2	2	2
3·7	1·924	1·926	1·929	1·931	1·934	1·937	1·939	1·942	1·944	1·947	0	1	1	1	1	2	2	2	2
3·8	1·949	1·952	1·955	1·957	1·960	1·962	1·965	1·967	1·970	1·972	0	1	1	1	1	2	2	2	2
3·9	1·975	1·977	1·980	1·982	1·985	1·988	1·990	1·993	1·995	1·998	0	1	1	1	1	2	2	2	2
4·0	2·000	2·003	2·005	2·008	2·010	2·013	2·015	2·017	2·020	2·022	0	0	1	1	1	1	2	2	2
4·1	2·025	2·027	2·030	2·032	2·035	2·037	2·040	2·042	2·045	2·047	0	0	1	1	1	1	2	2	2
4·2	2·049	2·052	2·054	2·057	2·059	2·062	2·064	2·066	2·069	2·071	0	0	1	1	1	1	2	2	2
4·3	2·074	2·076	2·078	2·081	2·083	2·086	2·088	2·091	2·093	2·095	0	0	1	1	1	1	2	2	2
4·4	2·098	2·100	2·102	2·105	2·107	2·110	2·112	2·114	2·117	2·119	0	0	1	1	1	1	2	2	2
4·5	2·121	2·124	2·126	2·128	2·131	2·133	2·135	2·138	2·140	2·142	0	0	1	1	1	1	2	2	2
4·6	2·145	2·147	2·149	2·152	2·154	2·156	2·159	2·161	2·163	2·166	0	0	1	1	1	1	2	2	2
4·7	2·168	2·170	2·173	2·175	2·177	2·179	2·182	2·184	2·186	2·189	0	0	1	1	1	1	2	2	2
4·8	2·191	2·193	2·195	2·198	2·200	2·202	2·205	2·207	2·209	2·211	0	0	1	1	1	1	2	2	2
4·9	2·214	2·216	2·218	2·220	2·223	2·225	2·227	2·229	2·232	2·234	0	0	1	1	1	1	2	2	2
5·0	2·236	2·238	2·241	2·243	2·245	2·247	2·249	2·252	2·254	2·256	0	0	1	1	1	1	2	2	2
5·1	2·258	2·261	2·263	2·265	2·267	2·269	2·272	2·274	2·276	2·278	0	0	1	1	1	1	2	2	2
5·2	2·280	2·283	2·285	2·287	2·289	2·291	2·294	2·296	2·298	2·300	0	0	1	1	1	1	2	2	2
5·3	2·302	2·304	2·307	2·309	2·311	2·313	2·315	2·317	2·320	2·322	0	0	1	1	1	1	2	2	2
5·4	2·324	2·326	2·328	2·330	2·332	2·335	2·337	2·339	2·341	2·343	0	0	1	1	1	1	1	2	2

Square Roots

											Mean Differences								
	0	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9
5·5	2·345	2·347	2·350	2·352	2·354	2·356	2·358	2·360	2·362	2·364	0	0	1	1	1	1	1	2	2
5·6	2·366	2·369	2·371	2·373	2·375	2·377	2·379	2·381	2·383	2·385	0	0	1	1	1	1	1	2	2
5·7	2·388	2·390	2·392	2·394	2·396	2·398	2·400	2·402	2·404	2·406	0	0	1	1	1	1	1	2	2
5·8	2·408	2·410	2·412	2·415	2·417	2·419	2·421	2·423	2·425	2·427	0	0	1	1	1	1	1	2	2
5·9	2·429	2·431	2·433	2·435	2·437	2·439	2·441	2·443	2·445	2·447	0	0	1	1	1	1	1	2	2
6·0	2·450	2·452	2·454	2·456	2·458	2·460	2·462	2·464	2·466	2·468	0	0	1	1	1	1	1	2	2
6·1	2·470	2·472	2·474	2·476	2·478	2·480	2·482	2·484	2·486	2·488	0	0	1	1	1	1	1	2	2
6·2	2·490	2·492	2·494	2·496	2·498	2·500	2·502	2·504	2·506	2·508	0	0	1	1	1	1	1	2	2
6·3	2·510	2·512	2·514	2·516	2·518	2·520	2·522	2·524	2·526	2·528	0	0	1	1	1	1	1	2	2
6·4	2·530	2·532	2·534	2·536	2·538	2·540	2·542	2·544	2·546	2·548	0	0	1	1	1	1	1	2	2
6·5	2·550	2·551	2·553	2·555	2·557	2·559	2·561	2·563	2·565	2·567	0	0	1	1	1	1	1	2	2
6·6	2·569	2·571	2·573	2·575	2·577	2·579	2·581	2·583	2·585	2·587	0	0	1	1	1	1	1	2	2
6·7	2·588	2·590	2·592	2·594	2·596	2·598	2·600	2·602	2·604	2·606	0	0	1	1	1	1	1	2	2
6·8	2·608	2·610	2·612	2·613	2·615	2·617	2·619	2·621	2·623	2·625	0	0	1	1	1	1	1	2	2
6·9	2·627	2·629	2·631	2·632	2·634	2·636	2·638	2·640	2·642	2·644	0	0	1	1	1	1	1	2	2
7·0	2·646	2·648	2·650	2·651	2·653	2·655	2·657	2·659	2·661	2·663	0	0	1	1	1	1	1	2	2
7·1	2·665	2·667	2·668	2·670	2·672	2·674	2·676	2·678	2·680	2·681	0	0	1	1	1	1	1	1	2
7·2	2·683	2·685	2·687	2·689	2·691	2·693	2·694	2·696	2·698	2·700	0	0	1	1	1	1	1	1	2
7·3	2·702	2·704	2·706	2·707	2·709	2·711	2·713	2·715	2·717	2·719	0	0	1	1	1	1	1	1	2
7·4	2·720	2·722	2·724	2·726	2·728	2·729	2·731	2·733	2·735	2·737	0	0	1	1	1	1	1	1	2
7·5	2·739	2·740	2·742	2·744	2·746	2·748	2·750	2·751	2·753	2·755	0	0	1	1	1	1	1	1	2
7·6	2·757	2·759	2·760	2·762	2·764	2·766	2·768	2·769	2·771	2·773	0	0	1	1	1	1	1	1	2
7·7	2·775	2·777	2·778	2·780	2·782	2·784	2·786	2·787	2·789	2·791	0	0	1	1	1	1	1	1	2
7·8	2·793	2·795	2·796	2·798	2·800	2·802	2·804	2·805	2·807	2·809	0	0	1	1	1	1	1	1	2
7·9	2·811	2·812	2·814	2·816	2·818	2·820	2·821	2·823	2·825	2·827	0	0	1	1	1	1	1	1	2
8·0	2·828	2·830	2·832	2·834	2·835	2·837	2·839	2·841	2·843	2·844	0	0	1	1	1	1	1	1	2
8·1	2·846	2·848	2·850	2·851	2·853	2·855	2·857	2·858	2·860	2·862	0	0	1	1	1	1	1	1	2
8·2	2·864	2·865	2·867	2·869	2·871	2·872	2·874	2·876	2·877	2·879	0	0	1	1	1	1	1	1	2
8·3	2·881	2·883	2·884	2·886	2·888	2·890	2·891	2·893	2·895	2·897	0	0	1	1	1	1	1	1	2
8·4	2·898	2·900	2·902	2·903	2·905	2·907	2·909	2·910	2·912	2·914	0	0	1	1	1	1	1	1	2
8·5	2·915	2·917	2·919	2·921	2·922	2·924	2·926	2·927	2·929	2·931	0	0	1	1	1	1	1	1	2
8·6	2·933	2·934	2·936	2·938	2·939	2·941	2·943	2·944	2·946	2·948	0	0	1	1	1	1	1	1	2
8·7	2·950	2·951	2·953	2·955	2·956	2·958	2·960	2·961	2·963	2·965	0	0	1	1	1	1	1	1	2
8·8	2·966	2·968	2·970	2·972	2·973	2·975	2·977	2·978	2·980	2·982	0	0	1	1	1	1	1	1	2
8·9	2·983	2·985	2·987	2·988	2·990	2·992	2·993	2·995	2·997	2·998	0	0	1	1	1	1	1	1	2
9·0	3·000	3·002	3·003	3·005	3·007	3·008	3·010	3·012	3·013	3·015	0	0	0	1	1	1	1	1	1
9·1	3·017	3·018	3·020	3·022	3·023	3·025	3·027	3·028	3·030	3·032	0	0	0	1	1	1	1	1	1
9·2	3·033	3·035	3·036	3·038	3·040	3·041	3·043	3·045	3·046	3·048	0	0	0	1	1	1	1	1	1
9·3	3·050	3·051	3·053	3·055	3·056	3·058	3·059	3·061	3·063	3·064	0	0	0	1	1	1	1	1	1
9·4	3·066	3·068	3·069	3·071	3·072	3·074	3·076	3·077	3·079	3·081	0	0	0	1	1	1	1	1	1
9·5	3·082	3·084	3·085	3·087	3·089	3·090	3·092	3·094	3·095	3·097	0	0	0	1	1	1	1	1	1
9·6	3·098	3·100	3·102	3·103	3·105	3·106	3·108	3·110	3·111	3·113	0	0	0	1	1	1	1	1	1
9·7	3·115	3·116	3·118	3·119	3·121	3·123	3·124	3·126	3·127	3·129	0	0	0	1	1	1	1	1	1
9·8	3·131	3·132	3·134	3·135	3·137	3·139	3·140	3·142	3·143	3·145	0	0	0	1	1	1	1	1	1
9·9	3·146	3·148	3·150	3·151	3·153	3·154	3·156	3·158	3·159	3·161	0	0	0	1	1	1	1	1	1

Square Roots

											Mean Differences								
	0	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9
10	3·162	3·178	3·194	3·209	3·225	3·240	3·256	3·271	3·286	3·302	2	3	5	6	8	9	11	12	14
11	3·317	3·332	3·347	3·362	3·376	3·391	3·406	3·421	3·435	3·450	1	3	4	6	7	9	10	12	13
12	3·464	3·479	3·493	3·507	3·521	3·536	3·550	3·564	3·578	3·592	1	3	4	6	7	8	10	11	13
13	3·606	3·619	3·633	3·647	3·661	3·674	3·688	3·701	3·715	3·728	1	3	4	5	7	8	10	11	12
14	3·742	3·755	3·768	3·782	3·795	3·808	3·821	3·834	3·847	3·860	1	3	4	5	7	8	9	11	12
15	3·873	3·886	3·899	3·912	3·924	3·937	3·950	3·962	3·975	3·988	1	3	4	5	6	8	9	10	11
16	4·000	4·012	4·025	4·037	4·050	4·062	4·074	4·087	4·099	4·111	1	2	4	5	6	7	9	10	11
17	4·123	4·135	4·147	4·159	4·171	4·183	4·195	4·207	4·219	4·231	1	2	4	5	6	7	8	10	11
18	4·243	4·254	4·266	4·278	4·290	4·301	4·313	4·324	4·336	4·347	1	2	3	5	6	7	8	9	10
19	4·359	4·370	4·382	4·393	4·405	4·416	4·427	4·438	4·450	4·461	1	2	3	5	6	7	8	9	10
20	4·472	4·483	4·494	4·506	4·517	4·528	4·539	4·550	4·561	4·572	1	2	3	4	6	7	8	9	10
21	4·583	4·594	4·604	4·615	4·626	4·637	4·648	4·658	4·669	4·680	1	2	3	4	5	6	8	9	10
22	4·690	4·701	4·712	4·722	4·733	4·743	4·754	4·765	4·775	4·785	1	2	3	4	5	6	7	8	9
23	4·796	4·806	4·817	4·827	4·837	4·848	4·858	4·868	4·879	4·889	1	2	3	4	5	6	7	8	9
24	4·899	4·909	4·919	4·930	4·940	4·950	4·960	4·970	4·980	4·990	1	2	3	4	5	6	7	8	9
25	5·000	5·010	5·020	5·030	5·040	5·050	5·060	5·070	5·079	5·089	1	2	3	4	5	6	7	8	9
26	5·099	5·109	5·119	5·128	5·138	5·148	5·158	5·167	5·177	5·187	1	2	3	4	5	6	7	8	9
27	5·196	5·206	5·215	5·225	5·235	5·244	5·254	5·263	5·273	5·282	1	2	3	4	5	6	7	8	9
28	5·292	5·301	5·310	5·320	5·329	5·339	5·348	5·357	5·367	5·376	1	2	3	4	5	6	7	7	8
29	5·385	5·394	5·404	5·413	5·422	5·431	5·441	5·450	5·459	5·468	1	2	3	4	5	5	6	7	8
30	5·477	5·486	5·495	5·505	5·514	5·523	5·532	5·541	5·550	5·559	1	2	3	4	4	5	6	7	8
31	5·568	5·577	5·586	5·595	5·604	5·612	5·621	5·630	5·639	5·648	1	2	3	3	4	5	6	7	8
32	5·657	5·666	5·675	5·683	5·692	5·701	5·710	5·718	5·727	5·736	1	2	3	3	4	5	6	7	8
33	5·745	5·753	5·762	5·771	5·779	5·788	5·797	5·805	5·814	5·822	1	2	3	3	4	5	6	7	8
34	5·831	5·840	5·848	5·857	5·865	5·874	5·882	5·891	5·899	5·908	1	2	3	3	4	5	6	7	8
35	5·916	5·925	5·933	5·941	5·950	5·958	5·967	5·975	5·983	5·992	1	2	2	3	4	5	6	7	8
35	6·000	6·008	6·017	6·025	6·033	6·042	6·050	6·058	6·066	6·075	1	2	2	3	4	5	6	7	7
37	6·083	6·091	6·099	6·107	6·116	6·124	6·132	6·140	6·148	6·156	1	2	2	3	4	5	6	7	7
38	6·164	6·173	6·181	6·189	6·197	6·205	6·213	6·221	6·229	6·237	1	2	2	3	4	5	6	6	7
39	6·245	6·253	6·261	6·269	6·277	6·285	6·293	6·301	6·309	6·317	1	2	2	3	4	5	6	6	7
40	6·325	6·332	6·340	6·348	6·356	6·364	6·372	6·380	6·387	6·395	1	2	2	3	4	5	6	6	7
41	6·403	6·411	6·419	6·427	6·434	6·442	6·450	6·458	6·465	6·473	1	2	2	3	4	5	5	6	7
42	6·481	6·488	6·496	6·504	6·512	6·519	6·527	6·535	6·542	6·550	1	2	2	3	4	5	5	6	7
43	6·557	6·565	6·573	6·580	6·588	6·595	6·603	6·611	6·618	6·626	1	2	2	3	4	5	5	6	7
44	6·633	6·641	6·648	6·656	6·663	6·671	6·678	6·686	6·693	6·701	1	2	2	3	4	5	5	6	7
45	6·708	6·716	6·723	6·731	6·738	6·745	6·753	6·760	6·768	6·775	1	1	2	3	4	4	5	6	7
46	6·782	6·790	6·797	6·804	6·812	6·819	6·826	6·834	6·841	6·848	1	1	2	3	4	4	5	6	7
47	6·856	6·863	6·870	6·878	6·885	6·892	6·899	6·907	6·914	6·921	1	1	2	3	4	4	5	6	7
48	6·928	6·935	6·943	6·950	6·957	6·964	6·971	6·979	6·986	6·993	1	1	2	3	4	4	5	6	6
49	7·000	7·007	7·014	7·021	7·029	7·036	7·043	7·050	7·057	7·064	1	1	2	3	4	4	5	6	6
50	7·071	7·078	7·085	7·092	7·099	7·106	7·113	7·120	7·127	7·134	1	1	2	3	4	4	5	6	6
51	7·141	7·148	7·155	7·162	7·169	7·176	7·183	7·190	7·197	7·204	1	1	2	3	4	4	5	6	6
52	7·211	7·218	7·225	7·232	7·239	7·246	7·253	7·259	7·266	7·273	1	1	2	3	3	4	5	6	6
53	7·280	7·287	7·294	7·301	7·308	7·314	7·321	7·328	7·335	7·342	1	1	2	3	3	4	5	5	6
54	7·349	7·355	7·362	7·369	7·376	7·382	7·389	7·396	7·403	7·410	1	1	2	3	3	4	5	5	6

Square Roots

											Mean Differences								
	0	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9
55	7·416	7·423	7·430	7·436	7·443	7·450	7·457	7·463	7·470	7·477	1	1	2	3	3	4	5	5	6
56	7·483	7·490	7·497	7·503	7·510	7·517	7·523	7·530	7·537	7·543	1	1	2	3	3	4	5	5	6
57	7·550	7·556	7·563	7·570	7·576	7·583	7·589	7·596	7·603	7·609	1	1	2	3	3	4	5	5	6
58	7·616	7·622	7·629	7·635	7·642	7·649	7·655	7·662	7·668	7·675	1	1	2	3	3	4	5	5	6
59	7·681	7·688	7·694	7·701	7·707	7·714	7·720	7·727	7·733	7·740	1	1	2	3	3	4	4	5	6
60	7·746	7·752	7·759	7·765	7·772	7·778	7·785	7·791	7·797	7·804	1	1	2	3	3	4	4	5	6
61	7·810	7·817	7·823	7·829	7·836	7·842	7·849	7·855	7·861	7·868	1	1	2	3	3	4	4	5	6
62	7·874	7·880	7·887	7·893	7·899	7·906	7·912	7·918	7·925	7·931	1	1	2	3	3	4	4	5	6
63	7·937	7·944	7·950	7·956	7·962	7·969	7·975	7·981	7·987	7·994	1	1	2	3	3	4	4	5	6
64	8·000	8·006	8·012	8·019	8·025	8·031	8·037	8·044	8·050	8·056	1	1	2	2	3	4	4	5	6
65	8·062	8·068	8·075	8·081	8·087	8·093	8·099	8·106	8·112	8·118	1	1	2	2	3	4	4	5	6
66	8·124	8·130	8·136	8·142	8·149	8·155	8·161	8·167	8·173	8·179	1	1	2	2	3	4	4	5	5
67	8·185	8·191	8·198	8·204	8·210	8·216	8·222	8·228	8·234	8·240	1	1	2	2	3	4	4	5	5
68	8·246	8·252	8·258	8·264	8·270	8·276	8·283	8·289	8·295	8·301	1	1	2	2	3	4	4	5	5
69	8·307	8·313	8·319	8·325	8·331	8·337	8·343	8·349	8·355	8·361	1	1	2	2	3	4	4	5	5
70	8·367	8·373	8·379	8·385	8·390	8·396	8·402	8·408	8·414	8·420	1	1	2	2	3	4	4	5	5
71	8·426	8·432	8·438	8·444	8·450	8·456	8·462	8·468	8·473	8·479	1	1	2	2	3	4	4	5	5
72	8·485	8·491	8·497	8·503	8·509	8·515	8·521	8·526	8·532	8·538	1	1	2	2	3	3	4	5	5
73	8·544	8·550	8·556	8·562	8·567	8·573	8·579	8·585	8·591	8·597	1	1	2	2	3	3	4	5	5
74	8·602	8·608	8·614	8·620	8·626	8·631	8·637	8·643	8·649	8·654	1	1	2	2	3	3	4	5	5
75	8·660	8·666	8·672	8·678	8·683	8·689	8·695	8·701	8·706	8·712	1	1	2	2	3	3	4	5	5
76	8·718	8·724	8·729	8·735	8·741	8·746	8·752	8·758	8·764	8·769	1	1	2	2	3	3	4	5	5
77	8·775	8·781	8·786	8·792	8·798	8·803	8·809	8·815	8·820	8·826	1	1	2	2	3	3	4	4	5
78	8·832	8·837	8·843	8·849	8·854	8·860	8·866	8·871	8·877	8·883	1	1	2	2	3	3	4	4	5
79	8·888	8·894	8·899	8·905	8·911	8·916	8·922	8·927	8·933	8·939	1	1	2	2	3	3	4	4	5
80	8·944	8·950	8·955	8·961	8·967	8·972	8·978	8·983	8·989	8·994	1	1	2	2	3	3	4	4	5
81	9·000	9·006	9·011	9·017	9·022	9·028	9·033	9·039	9·044	9·050	1	1	2	2	3	3	4	4	5
82	9·055	9·061	9·066	9·072	9·077	9·083	9·088	9·094	9·099	9·105	1	1	2	2	3	3	4	4	5
83	9·110	9·116	9·121	9·127	9·132	9·138	9·143	9·149	9·154	9·160	1	1	2	2	3	3	4	4	5
84	9·165	9·171	9·176	9·182	9·187	9·192	9·198	9·203	9·209	9·214	1	1	2	2	3	3	4	4	5
85	9·220	9·225	9·230	9·236	9·241	9·247	9·252	9·257	9·263	9·268	1	1	2	2	3	3	4	4	5
86	9·274	9·279	9·284	9·290	9·295	9·301	9·306	9·311	9·317	9·322	1	1	2	2	3	3	4	4	5
87	9·327	9·333	9·338	9·343	9·349	9·354	9·359	9·365	9·370	9·375	1	1	2	2	3	3	4	4	5
88	9·381	9·386	9·391	9·397	9·402	9·407	9·413	9·418	9·423	9·429	1	1	2	2	3	3	4	4	5
89	9·434	9·439	9·445	9·450	9·455	9·460	9·466	9·471	9·476	9·482	1	1	2	2	3	3	4	4	5
90	9·487	9·492	9·497	9·503	9·508	9·513	9·518	9·524	9·529	9·534	1	1	2	2	3	3	4	4	5
91	9·539	9·545	9·550	9·555	9·560	9·566	9·571	9·576	9·581	9·586	1	1	2	2	3	3	4	4	5
92	9·592	9·597	9·602	9·607	9·613	9·618	9·623	9·628	9·633	9·638	1	1	2	2	3	3	4	4	5
93	9·644	9·649	9·654	9·659	9·664	9·670	9·675	9·680	9·685	9·690	1	1	2	2	3	3	4	4	5
94	9·695	9·701	9·706	9·711	9·716	9·721	9·726	9·731	9·737	9·742	1	1	2	2	3	3	4	4	5
95	9·747	9·752	9·757	9·762	9·767	9·772	9·778	9·783	9·788	9·793	1	1	2	2	3	3	4	4	5
96	9·798	9·803	9·808	9·813	9·818	9·823	9·829	9·834	9·839	9·844	1	1	2	2	3	3	4	4	5
97	9·849	9·854	9·859	9·864	9·869	9·874	9·879	9·884	9·889	9·894	1	1	1	2	3	3	4	4	5
98	9·900	9·905	9·910	9·915	9·920	9·925	9·930	9·935	9·940	9·945	0	1	1	2	2	3	3	4	4
99	9·950	9·955	9·960	9·965	9·970	9·975	9·980	9·985	9·990	9·995	0	1	1	2	2	3	3	4	4

Squares

	0	1	2	3	4	5	6	7	8	9
0	0	1	4	9	16	25	36	49	64	81
1	100	121	144	169	196	225	256	289	324	361
2	400	441	484	529	576	625	676	729	784	841
3	900	961	1024	1089	1156	1225	1296	1369	1444	1521
4	1600	1681	1764	1849	1936	2025	2116	2209	2304	2401
5	2500	2601	2704	2809	2916	3025	3136	3249	3364	3481
6	3600	3721	3844	3969	4096	4225	4356	4489	4624	4761
7	4900	5041	5184	5329	5476	5625	5776	5929	6084	6241
8	6400	6561	6724	6889	7056	7225	7396	7569	7744	7921
9	8100	8281	8464	8649	8836	9025	9216	9409	9604	9801
10	10000	10201	10404	10609	10816	11025	11236	11449	11664	11881
11	12100	12321	12544	12769	12996	13225	13456	13689	13924	14161
12	14400	14641	14884	15129	15376	15625	15876	16129	16384	16641
13	16900	17161	17424	17689	17956	18225	18496	18769	19044	19321
14	19600	19881	20164	20449	20736	21025	21316	21609	21904	22201
15	22500	22801	23104	23409	23716	24025	24336	24649	24964	25281
16	25600	25921	26244	26569	26896	27225	27556	27889	28224	28561
17	28900	29241	29584	29929	30276	30625	30976	31329	31684	32041
18	32400	32761	33124	33489	33856	34225	34596	34969	35344	35721
19	36100	36481	36864	37249	37636	38025	38416	38809	39204	39601
20	40000	40401	40804	41209	41616	42025	42436	42849	43264	43681
21	44100	44521	44944	45369	45796	46225	46656	47089	47524	47961
22	48400	48841	49284	49729	50176	50625	51076	51529	51984	52441
23	52900	53361	53824	54289	54756	55225	55696	56169	56644	57121
24	57600	58081	58564	59049	59536	60025	60516	61009	61504	62001
25	62500	63001	63504	64009	64516	65025	65536	66049	66564	67081
26	67600	68121	68644	69169	69696	70225	70756	71289	71824	72361
27	72900	73441	73984	74529	75076	75625	76176	76729	77284	77841
28	78400	78961	79524	80089	80656	81225	81796	82369	82944	83521
29	84100	84681	85264	85849	86436	87025	87616	88209	88804	89401
30	90000	90601	91204	91809	92416	93025	93636	94249	94864	95481
31	96100	96721	97344	97969	98596	99225	99856	100489	101124	101761
32	102400	103041	103684	104329	104976	105625	106276	106929	107584	108241
33	108900	109561	110224	110889	111556	112225	112896	113569	114244	114921
34	115600	116281	116964	117649	118336	119025	119716	120409	121104	121801
35	122500	123201	123904	124609	125316	126025	126736	127449	128164	128881
36	129600	130321	131044	131769	132496	133225	133956	134689	135424	136161
37	136900	137641	138384	139129	139876	140625	141376	142129	142884	143641
38	144400	145161	145924	146689	147456	148225	148996	149769	150544	151321
39	152100	152881	153664	154449	155236	156025	156816	157609	158404	159201
40	160000	160801	161604	162409	163216	164025	164836	165649	166464	167281
41	168100	168921	169744	170569	171396	172225	173056	173889	174724	175561
42	176400	177241	178084	178929	179776	180625	181476	182329	183184	184041
43	184900	185761	186624	187489	188356	189225	190096	190969	191844	192721
44	193600	194481	195364	196249	197136	198025	198916	199809	200704	201601
45	202500	203401	204304	205209	206116	207025	207936	208849	209764	210681
46	211600	212521	213444	214369	215296	216225	217156	218089	219024	219961
47	220900	221841	222784	223729	224676	225625	226576	227529	228484	229441
48	230400	231361	232324	233289	234256	235225	236196	237169	238144	239121
49	240100	241081	242064	243049	244036	245025	246016	247009	248004	249001

Squares

	0	1	2	3	4	5	6	7	8	9
50	250000	251001	252004	253009	254016	255025	256036	257049	258064	259081
51	260100	261121	262144	263169	264196	265225	266256	267289	268324	269361
52	270400	271441	272484	273529	274576	275625	276676	277729	278784	279841
53	280900	281961	283024	284089	285156	286225	287296	288369	289444	290521
54	291600	292681	293764	294849	295936	297025	298116	299209	300304	301401
55	302500	303601	304704	305809	306916	308025	309136	310249	311364	312481
56	313600	314721	315844	316969	318096	319225	320356	321489	322624	323761
57	324900	326041	327184	328329	329476	330625	331776	332929	334084	335241
58	336400	337561	338724	339889	341056	342225	343396	344569	345744	346921
59	348100	349281	350464	351649	352836	354025	355216	356409	357604	358801
60	360000	361201	362404	363609	364816	366025	367236	368449	369664	370881
61	372100	373321	374544	375769	376996	378225	379456	380689	381924	383161
62	384400	385641	386884	388129	389376	390625	391876	393129	394384	395641
63	396900	398161	399424	400689	401956	403225	404496	405769	407044	408321
64	409600	410881	412164	413449	414736	416025	417316	418609	419904	421201
65	422500	423801	425104	426409	427716	429025	430336	431649	432964	434281
66	435600	436921	438244	439569	440896	442225	443556	444889	446224	447561
67	448900	450241	451584	452929	454276	455625	456976	458329	459684	461041
68	462400	463761	465124	466489	467856	469225	470596	471969	473344	474721
69	476100	477481	478864	480249	481636	483025	484416	485809	487204	488601
70	490000	491401	492804	494209	495616	497025	498436	499849	501264	502681
71	504100	505521	506944	508369	509796	511225	512656	514089	515524	516961
72	518400	519841	521284	522729	524176	525625	527076	528529	529984	531441
73	532900	534361	535824	537289	538756	540225	541696	543169	544644	546121
74	547600	549081	550564	552049	553536	555025	556516	558009	559504	561001
75	562500	564001	565504	567009	568516	570025	571536	573049	574564	576081
76	577600	579121	580644	582169	583696	585225	586756	588289	589824	591361
77	592900	594441	595984	597529	599076	600625	602176	603729	605284	606841
78	608400	609961	611524	613089	614656	616225	617796	619369	620944	622521
79	624100	625681	627264	628849	630436	632025	633616	635209	636804	638401
80	640000	641601	643204	644809	646416	648025	649636	651249	652864	654481
81	656100	657721	659344	660969	662596	664225	665856	667489	669124	670761
82	672400	674041	675684	677329	678976	680625	682276	683929	685584	687241
83	688900	690561	692224	693889	695556	697225	698896	700569	702244	703921
84	705600	707281	708964	710649	712336	714025	715716	717409	719104	720801
85	722500	724201	725904	727609	729316	731025	732736	734449	736164	737881
86	739600	741321	743044	744769	746496	748225	749956	751689	753424	755161
87	756900	758641	760384	762129	763876	765625	767376	769129	770884	772641
88	774400	776161	777924	779689	781456	783225	784996	786769	788544	790321
89	792100	793881	795664	797449	799236	801025	802816	804609	806404	808201
90	810000	811801	813604	815409	817216	819025	820836	822649	824464	826281
91	828100	829941	831744	833569	835396	837225	839056	840889	842724	844561
92	846400	848241	850084	851929	853776	855625	857476	859329	861184	863041
93	864900	866761	868624	870489	872356	874225	876096	877969	879844	881721
94	883600	885481	887364	889249	891136	893025	894916	896809	898704	900601
95	902500	904401	906304	908209	910116	912025	913936	915849	917764	919681
96	921600	923521	925444	927369	929296	931225	933156	935089	937024	938961
97	940900	942841	944784	946729	948676	950625	952576	954529	956484	958441
98	960400	962361	964324	966289	968256	970225	972196	974169	976144	978121
99	980100	982081	984064	986049	988036	990025	992016	994009	996004	998001

APPENDIX

Introduction to SI UNITS

Length, Mass and Time are generally accepted as the three base physical quantities involved in any system of physical measurement of mechanical phenomena. If units are arbitrarily defined for measuring these quantities then a complete system of derived units for measuring other quantities can be built by applying the defining relations established from the appropriate physical laws. The base units together with the corresponding derived units will form a complete and coherent system of units. There are two systems in general use—one is the CGS system in which the centimetre, gram and second are the base units of length, mass and time. The other is the FPS system in which the corresponding base units are the foot, pound and second. Both are absolute systems. In the field of Engineering and Technology, however, other systems named the gravitational systems of units are being used. The metre, the kilogram force and the second are the base units in the metric gravitational system. The foot, the pound force and the second are the base units of the analogous FPS system. In these systems the unit of mass is a derived one.

Electrical measurements require an additional base unit. Electrical phenomena are related to mechanical phenomena by two effects (1) the force between static electrical charges (Coulomb's law) and (2) the force between electric currents (Ampere's law). Correspondingly two distinct systems of CGS electrical units were developed, the CGS electrostatic and the CGS electromagnetic. In the CGS electrostatic system the permittivity of free space ϵ_0 is arbitrarily given the value of unity and in the CGS electromagnetic system, the permeability of free space μ_0 is arbitrarily assigned the value of unity. The two systems of units are defined, each uniquely. However, these two systems cannot be combined directly to form a single consistent system, as according to Maxwell's Electromagnetic theory, in any consistent system of units, $\mu_0 \epsilon_0$ should be equal to $1/c^2$ where c is the velocity of electromagnetic radiation in free space.

Neither of these systems has units of convenient size for practical applications. Consequently a set of practical electrical units (coulomb, ampere, volt, ohm, henry, farad, watt etc.) each being a definite decimal multiple of the corresponding CGS em unit was established. However, it was not made into a complete system, as no separate magnetic units were defined. The CGS em unit of magnetic field strength, the *oersted* and of magnetic flux, the *maxwell* were still maintained.

MKSA system

Further simplication was achieved when in 1938 the Electrotechnical Commission accepted the recommendations of Prof. Giorgi and adopted the metre, kilogram and second as the base units of length, mass and time. A great advantage of this system is that its units are identical with the already firmly established practical units like the joule, watt, ampere, coulomb etc. The connecting link between the electrical and mechanical units in this system is the ampere which is defined as a base unit. The permeability (μ_0) of free space in this system works out to be 10^{-7}. As $\frac{1}{\sqrt{\mu_0 \epsilon_0}} = c$ the velocity of light, in this system named the unrationalized MKSA system, $\epsilon_0 = 1{\cdot}113 \times 10^{-10}$.

Rationalized MKSA (RMKSA) System

The concept of unit flux issuing from unit magnetic pole and from unit charge is the basis of the rationalized (RMKSA) system of units. In this system $\mu_0 = 4\pi \times 10^{-7}$ instead of 10^{-7} in the unrationalized system and

$$\epsilon_0 = \frac{1{\cdot}113 \times 10^{-10}}{4\pi} = 8{\cdot}854 \times 10^{-12}$$

Over a number of years a mass of scientific data have been expressed in the units of the various systems and considerable mental effort is required to make use of them when needed. To simplify the matter a more comprehensive system founded on six base units, the metre, kilogram, second and ampere of the RMKSA system with the addition of the degree kelvin and the candela (unit of luminous intensity) was adopted by the Tenth International Conference of Weights and Measures in 1954. Thus the RMKSA system of units was extended to measurements in thermodynamic and photometric fields. In 1960, the 11th General Conference designated the new system as the system Internationale d'units for which the abbreviation is SI. The SI system of units is replacing the other systems in Science, Technology, Industry and Commerce. A seventh base unit named the 'mole' has since been added to express an amount of substance in terms of a fixed number of constituent parts.

In addition, two supplementary units are at present defined, the radian and the steradian, which are the units of plane and solid angles respectively.

The important features of SI are

1. It is comprehensive and fit for world wide use in all branches of Science, Engineering, Technology, Commerce and Industry.

2. The number of base, independent units is kept to the minimum consistent with convenience. There are seven only.

3. All other measures of force, energy, density and so on are derived units, constructed from the base units without numerical factors or arbitrary constants. It is thus a coherent system. A system of units is said to be coherent if the product or quotient of any two unit quantities in the system gives the unit of the resultant quantity.

4. It is an absolute system as opposed to Gravitational where the appearance of 'g' often causes confusion and mental strain.

5. Derived units in common use are given internationally agreed names. Most named units are already well established and familiar.

6. The multiples and submultiples of units required to give them an adequate range are restricted by recommendation.

7. Certain units extensively and internationally used in special fields are retained for the present although they do not form part of the system.

Mechanical Units in SI, CGS, FPS Systems

Quantity	Symbol	Dimensions	SI Unit	CGS Unit	Ratio CGS/SI units	FPS Unit	Ratio FPS/SI Units	Conversion factors
Length	l	L	metre (m)	centimetre (cm)	10^{-2}	foot (Ft)	0·304 8	1 slug=32·174 lb=14·594 kg
Mass	m	M	kilogram (kg)	gram (gm)	10^{-3}	pound (lb)	0·453 6	1 tonne=1000 kg
Time	t	T	second(s)	second(s)	1	second(s)	1	1 quintal=100 kg
Area,	A, S	L^2	m^2	cm^2	10^{-4}	ft^2	0·092 9	1 kgf=9·807 N
Volume	V	L^3	m^3	cm^3	10^{-6}	ft^3	0·028 3	1 lbf=32·17 pdl=4·448 N 1 lbf.ft=1·356 J(Nm)
Density	ρ	ML^{-3}	kg m^{-3}	gcm^{-3}	10^3	$lbft^{-3}$	16·018 5	1 atm=14·7 lbf/sq. in =1·013 bars
Velocity	u, v	LT^{-1}	ms^{-1}	cms^{-1}	10^{-2}	fts^{-1}	0·304 8	1 bar=10^5 Nm^{-2}=10^5P
Acceleration	a	LT^{-2}	ms^{-2}	cms^{-2} (gal)	10^{-2}	fts^{-2}	0·304 8	1 mm of Hg=1 torr
Momentum	p	MLT^{-1}	kg ms^{-1}	$gcms^{-1}$	10^{-5}	$lbfts^{-1}$	0·138 3	1 lbf/sq.in=1 p.s.i.=6 895 P
Moment of inertia	J, I	ML^2	kg m^2	gcm^2	10^{-7}	lbf^2	0·042 14	1 cal=4·186 8 J 1 therm=10^5 Btu
Angular momentum	L	ML^2T^{-1}	kg m^2 T^{-1}	gcm^2 s^{-1}	10^{-7}	$lbft^2$ s^{-1}	0·042 14	1 Btu=1 055 J=255 cals

Mechanical Units in SI, C.G.S. and FPS Systems (Contd.)

Quantity	Symbol	Dimensions	SI Unit	CGS Unit	Ratio CGS/SI units	FPS Unit	Ratio FPS/SI Units	Conversion factors
Force	F	$ML\ T^{-2}$	newton (N)	dyne	10^{-5}	poundal, $lbfts^{-2}$	0·138 3	1 C.H.U (Centi grade Heat Unit)=453·6 cals=189 9J
Energy or Work	E,W	ML^2T^{-2}	joule (J), Nm	erg, dyn-cm	10^{-7}	ft-poundal	0·042 14	
Power	P	ML^2T^{-3}	watt (W) Js^{-1}	erg s^{-1}	10^{-7}	Horse power	745·7	1 British horse power (h.p) =550 ft lbf/s=745·7 W
Pressure or stress	P	$ML^{-1}T^{-2}$	pascal (P) $=Nm^{-2}$	dyn cm^{-2}	10^{-1}	poundal/ft^2	1·489	
Surface Tension	γ	MT^{-2}	Nm^{-1}	dyn cm^{-1}	10^{-3}	poundal ft^{-1}	0·453 6	K=273·15+°C
Viscosity (dynamic)	η	$ML^{-1}T^{-1}$	$kgm^{-1}s^{-1}$ $(Nm^{-2}s)$	Poise (P)	10^{-1}	$lbf^{-1}\ s^{-1}$	1·488 6	
Viscosity (kinematic)	η/ρ	L^2T^{-1}	$m^2\ s^{-1}$	stoke(S)	10^{-4}	$ft^2\ s^{-1}$	0·092 9	1 cal/cm Ks=418·6 $Wm^{-1}\ K^{-1}$
Specific Volume	-	L^3M^{-1}	$m^3\ kg^{-1}$	$cm^3\ gm^{-1}$	10^{-3}	$ft^3\ lb^{-1}$	0·062 4	
Elastic Moduli	-	$ML^{-1}T^{-2}$	$kgm^{-1}s^{-2}$ $(P)Nm^{-2}$	dyn cm^{-2}	10^{-1}	Pdl ft^{-2}	1·489	Btu/hour=0·293 1 W
Frequency	v, f	T^{-1}	hertz (Hz)	cycles per second c/s	1	cycles per second c/s	1	Standard acceleration of Gravity=32·174 fts^{-2} =9·806 65 ms^{-2}

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SI, Electromagnetic and Electrostatic CGS Units

Quantity	Symbol	Dimensions (M K S A)	SI Unit	Symbol	Number of CGS electro-magnetic units in one SI unit	Number of CGS electro-static units in one SI unit	Number of CGS electro-static units in one CGS electromag-netic unit
Current	*I*	A	ampere	A	10^{-1}	10 C	100 C
Charge	*Q*	TA	coulomb	C	10^{-1}	10 C (franklin)	100 C
Potential difference	*V*	$ML^2 T^{-3} A^{-1}$	volt	V	10^8	$10^6/C$	1/100 C
Resistance	*R*	$ML^2 T^{-3} A^{-2}$	ohm	Ω	10^9	$10^5/C^2$	$1/(100 C)^2$
Conductance	*G*	$M^{-1} L^{-2} T^3 A^2$	siemens	S	10^{-9}	$C^2 10^{-5}$	$(100 C)^2$
Inductance	*L*	$ML^2 T^{-2} A^{-2}$	henry	H	10^9	$10^5/C^2$	$1/(100 C)^2$
Capacitance	*C*	$M^{-1} L^{-2} T^4 A^2$	farad	F	10^{-9}	$C^2 10^{-5}$	$(100 C)^2$
Magnetic flux	ϕ	$ML^2 T^{-2} A^{-1}$	weber	Wb	10^8 (Maxwell)	$10^6/C$	1/100 C
Magnetic Induction Flux density	*B*	$MT^{-2} A^{-1}$	tesla	T	10^4 (Gauss)	$10^2/C$	1/100 C
Magnetic field strength	*H*	$L^{-1} A$	ampere metre⁻¹	Am^{-1}	$4_\pi \times 10^{-3}$ (Oested)	$\frac{4\pi}{10} C$	100 C
Magnetization	*M*	$L^{-1} A$	ampere metre⁻¹	Am^{-1}	10^{-3}	$10^{-1} C$	100 C
Electric field strength	*E*	$ML T^{-3} A^{-1}$	volt metre⁻¹	Vm^{-1}	10^6	$10^4/C$	1/100 C
Elèctric displacement	*D*	$L^{-2} TA$	coulomb metre⁻²	Cm^{-2}	$4_\pi \times 10^{-5}$	$4_\pi \times 10^{-3} C$	100 C
Permittivity	ϵ	$M^{-1} L^{-3} T^4 A^2$	farad per metre	Fm^{-1}	$4_\pi \times 10^{-11}$	$4_\pi \times 10^{-7} C^2$	$(100 C)^2$
Permebility	μ	$ML T^{-2} A{-2}$	henry per metre	Hm^{-1}	$10^7/^4 \pi$	$10^3/4 \pi C^2$	$1/(100 C)^2$
Magnetomotive force	*Fm*	A	ampere (turn) A	A	$4_\pi \times 10{-1}$ Gilbert	$4 \pi \times 10 C$	100 C

Note: In CGS system magnetization was defined by the equation $B = H + 4_\pi M$
In SI adopting Sommerfeld system it is now defined by the equation $B = \mu_0 (H+M)$

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